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REPORT OF EXPERIMENTAL WORK DEALING WITH THE MATURITY, PRECOOLING, TRANSIT REFRIGERATION OF CALIFORNIA PLUMS DURING THE 1942 SEASON

(A cooperative investigation by the Bureau of Plant Industry, Agricultural Research Administration, U.S. Department of Agriculture; the Division of Pomology, California Agricultural Experiment Station; and the California Tree Fruit Agreement.)

BY

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INTRODUCTION

The experimental work begun last year on the maturity, precooling and transit refrigeration of plums was continued in 1942. One of the objects of repeating the work was to find if the different varieties and maturities behaved as they did in the previous season when growing conditions were not the same. The tests were expanded to include the President variety in addition to Beauty, Santa Rosa, Tragedy and Duarte. The precooling of vertical strip or Hoak loads 1/, was given particular attention and the temperatures attained in fan cars were investigated further. In the transit temperature studies, thermometers were packed in crates in other parts of the load besides the top layer of the doorway stack and bottom layer of the bunker stack used last year, in order to obtain a more complete record of refrigeration in transit. The possibility of using solid carbon dioxide or "dry ice" to supplement the refrigeration of plums in transit was also investigated, since tests by several other workers had indicated that it had a marked effect in retarding ripening. The question considered was whether or not concentrations could be held high enough in commercial shipments to be of benefit.

METHODS

The methods used were similar to those of 1941. Random samples of crates of plums from the usual commercial pack and selected crates of the greenest and ripest fruit packed for the eastern shipment were used in the test shipments. Color photographs were made of the plums at shipping point and again upon arrival, care being taken to eliminate avoidable differences in color reproduction. Descriptions were made of the firmness, ground color, the amount and intensity of over-color and general appearance of the fruit when it was packed, when it arrived at the market and again after it was ripe. The flavor of the ripe fruit was systematically scored to determine if it had poor, acceptable, good, or superior quality. The amounts of decay and other defects were likewise noted. The condition of the fruit in respect to market preference was ascertained by interviewing the buyers at the auction and other buyers as well. Market preference was found to be a variable thing depending upon supplies and demand, yet certain limits could be set within which most plums would be acceptable.

Temperatures in various parts of the load were read during precooling with distant-reading electric resistance thermometers. Recording thermometers, packed in the center of the crates, provided a record of the temperatures the plums were exposed to from time of loading until they were unloaded. These records were called "transit

1/ In the vertical strip or Hoak load the plum crates are loaded crosswise in the car. Boards 4 inches wide of 1/2 inch material with 2 inch cleats nailed to each face are placed upright between rows, the crates being loaded against the boards, the cleats separating the rows and preventing sidewise shifting. Because the heavy end piece is exposed to the air channel and the vertical strips block horizontal movement of air, cooling was expected to be slower in this load than in the lengthwise load.

temperatures" and it will be noted that they included the precooling or preshipping period as well as the time the fruit was actually in transit.

When it was possible to do so, comparisons were made between cars that were handled differently, that is, precooled or not precooled or precooled to different temperatures; fan car versus standard car; or treatment with dry ice compared to no treatment. Test packages of similar fruit were loaded in the same respective positions in both cars. Comparisons were sometimes made between the cool and warm parts of the same car. Twenty-seven test cars were shipped, 6 of which were Beauty, 9 Santa Rosa, 5 Tragedy, 3 Duarte, and 4 President plums (table 1).

Some lots of plums were held at Davis in connection with the studies on carbon dioxide treatment and ripening temperature; but samples from each shipment were not held in storage as was done last season, this duplication of work being eliminated in order to same time and money.

It will be noticed that the maturity of the fruit has been referred to in some cases by number. This was done to simplify description of the plums and tabulation of inspection data. The important point in this connection is that maturity 3 of each variety was fruit meeting the minimum maturity requirements established in the grade regulations of the Tree Fruit Agreement. In some instances maturity 3 possessed only equivalent maturity, lacking the required overcolor or flesh color. Fruit about one stage riper than the minimum maturity was called maturity 4. Maturity 5 was two stages riper than maturity 3 and was representative of the ripest fruit packed for eastern shipment. The commercial maturity was an assortment of plums ranging from maturity 3 to 5.

RESULTS

Arrival condition as affected by transit temperature and maturity.

BEAUTY PLUMS

Test cars 1 and 2:

Test shipments of Beauty plums were made in 6 cars all from the San Joaquin Valley. The first two cars were shipped on June 2 at the start of the season in Kern County and no precooling and short precooling of fan cars was compared. Both cars were shipped standard refrigeration, with the nonprecooled car receiving 2 percent salt at all icings as far as Chicago and the other car getting one application of salt, 3 percent, at the first icing station only. Both of the cars had too low temperatures (figure 1) for the barely passing plums that made up most of the load. This fruit when packed was yellowish green to greenish yellow with no pink and little yellow in evidence. It arrived with too little red color to please the trade and its lack of

good flavor when ripened also indicated that it was picked too green for best satisfaction

In both cars, riper fruit having about 10 percent pink color when packed arrived in good condition for auction display, showing 45 and 55 percent reddish color respectively in cars 1 and 2. Transit temperatures were lower in precooled car 1 where they averaged 44°F. for top layer doorway, than they were in nonprecooled car 2 which had 48° average temperature for this position, despite the more frequent salting it received in transit.

Test car 3:

The next test was made 3 days later at the start of Beauty shipments in the Reedley district. It indicated what could be expected of early shipments in a moderately precooled fan car (47°F. at the end of precooling), Hoak load, shipped standard refrigeration, 3 percent salt at all icing stations. Transit temperatures were fairly cool, averaging 46° for top layer doorway position and 39° for bottom layer bunker stack. The commercial consignment from this car, fruit having none to 20 percent pink color, mostly about 5 percent when packed, was a little too green for best demand when it was displayed on the auction for it had only 10 to 15 percent reddish color, The test lots of fruit of minimum maturity (trace of pink, 10 percent straw color) also arrived too green in both top and bottom layers of the car. The only fruit in this car that was not too green upon arrival was fruit that showed about 15 percent pink colorwhen it was packed. It was in perfect condition for the auction from the bottom layer bunker stack with 20 percent red color, and at the top layer doorway stack it had 60 percent red colorand was still within the range of color in demand by the buyers.

Test car 4:

A midseason shipment of Beauty plums was made from the Reedley district on June 8 in a standard car, Hoak load, shipped standard refrigeration with no salt applied in transit. This was a test to find if the short precooling many cars receive, (6 hours in this case), was enough for midseason shipments of this variety in standard cars. Average transit temperatures, indicated below, were considerably higher than in test cars 1, 2 and 3, these being fan cars.

Top layer, quarter length	53°F.	Bottom layer, doorway	44°F.
Top layer, bunker	52	Bottom layer, quarter lgth	44
Middle layer, quarter length	50	Bottom layer, bunker	38
Top layer, doorway	49		

The top layer of this car and much of the middle layer as well, where temperatures averaged 49° to 53°, proved to be too warm for even the greenest fruit packed (minimum maturity, mostly yellowish green, no pink color). It had almost full red color when it arrived and was much too ripe for the auction. Fruit picked at a riper stage of maturity, showing 10 percent pink color, arrived in good condition in the cool bottom layer where temperatures averaged 38° to 44°.

This test indicated clearly that a precooling period of six hours that cooled the fruit to 55°F. was not enough for even the greenest Beauty plums packed in midseason. It indicated also what was needed in the way of transit temperatures for this fruit and that picked at a riper stage of maturity. Average temperatures of 49° to 53° were not low enough; 38° to 44° were, for even riper fruit. For earlier picked fruit, slightly greener than that shipped in this car, 48° was low enough (test 2). As the season advances, the transit temperature may need to be lower for fruit of about the same apparent maturity as indicated by overcolor. Its actual maturity is usually more advanced, as evidenced by more yellowish ground color and lack of firmness as compared to earlier pickings.

Test car 8:

A final shipment of Beauty plums was made late in the season on June 16 to investigate the possibility of shipping fruit of advanced maturity in well refrigerated fan cars. This was a Hoak load, precooled for 9 hours to 48°, shipped standard refrigeration, 3 percent salt. The top layer, quarter length position had average temperatures in transit of 40° which was the best record of any Beauty car shipped in the 1942 tests. Despite favorable transit temperatures, the plums arrived too soft and ripe. This fruit was from the inside of the trees and was allowed to stay on the trees late in the season before picking. The plums had only 15 percent pink color but the ground color was mostly yellow instead of greenish yellow or yellowish green. Their advanced maturity was also evidenced by lack of hardness, most of the fruit being classed as firm ripe to ripe when shipped.

Discussion - Beauty Plums

The market preference for Beauty plums varied during the season. Early shipments were favorably received if they had enough pink to red color, about 50 to 60 percent, so that they were ready for immediate retail display. The general preference for later shipments fell into the 20 to 40 percent color range but as little as 10 to 15 percent red to pink color was often acceptable. This was about the same range of color as was desired in 1941.

Beauty plums showing as much as 10 to 15 percent pink color, provided they were hard to firm (maturity 4), arrived in very good condition for the auction when they were shipped in the bottom layers of all cars and even in the top layers of well refrigerated fan cars (see car 1). Average transit temperatures of 44° or less were apparently low enough for fruit of this maturity (table 2). Similar results were obtained in 1941 when bottom layers were found to be cool enough for plums with as much as 15 to 25 percent pink to red color.

Fruit of minimum maturity (showing no pink tips or a trace of pink with some straw color in evidence, and with most of the plum greenish yellow) needed transit temperatures that favored some color development such as were found in the top and middle layers of cars refrigerated moderately well. Temperatures of about 50° or above, such as were encountered in the top layer of a poorly precooled

standard car (car 4), were too high and transit temperatures averaging in the range of 38° to 44°, usually found in bottom layers of the cars, were too low (table 2). What was needed were temperatures averaging about 45° to 48°, such as could be obtained in the top layers of well cooled standard cars or moderately cooled fan cars. These results agree with those of 1941.

SANTA ROSA PLUMS

Test cars 5, 6 and 7:

Eight test shipments of Santa Rosa plums were made, the first of which was from Kern County on June 12 at the start of the commercial season. In this test a comparison was made between a fan car and a standard car, each precooled and shipped with two reicings in transit (cars 5 and 6), and a fan car precooled for only a few hours and shipped standard refrigeration with 2 percent salt (car 7).

Precooling in combination with air circulation in transit (car 5) resulted in top layer doorway temperatures of 43° in 24 hours, and slightly higher temperatures during the next few days which gradually lowered to 39° on arrival. The top quarter length was about 1° cooler during the trip and the middle quarter length was about the same temperature as top doorway. The bottom layers of the bunker and quarter length stacks were much alike in temperature, cooling to 45° in 24 hours and then to 39° at which they held for the rest of the trip.

The standard car had temperatures considerably higher than these, as shown in figure 2 (car 6). The poorly cooled fan car (car 7) cooled slowly regardless of the use of salt in transit or shipment under standard refrigeration. The average transit temperatures in these cars were as follows:

	Top doorway °F	Top quarter °F	Middle quarter °F	Bottom quarter °F	Bottom bunker °F
Car 5, cooled to 43°, fan car	45	41	42	41	42
Car 6, cooled to 47°, std. car	47	49	44	40	40
Car 7, cooled to 70°, fan car	49	-	-	-	-

The fruit displayed on the auction from car 5 was in excellent condition for the wholesale trade, showing about 50 percent red. One lot was 65 to 75 percent red, 5 percent of which was dark red and it was a little riper than desirable. Test car 6 was sold the following day, 11 days after shipment and the fruit in it was somewhat riper than in car 5, the plums having about 75 percent red color. This was to be expected because it was a warmer car and was sold one day later. Car 7 was unloaded early and trucked off the pier so that no inspection of the commercial pack was possible although there were reports that some of the fruit in it was overripe.

Fruit of minimum maturity (40 percent pink color when packed)

from the top doorway position of car 5 had about 45 percent red color on arrival and was at the lower limit of color for best auction display. In car 6, where transit temperatures were warmer, plums of this maturity arrived in good condition with about 85 percent pink to red color with none of the plums ripe. This maturity, shipped in car 7, where cooling was slow in transit, arrived showing 95 percent red color with 8 percent of the fruit dark red and too ripe for best demand. This test demonstrated that plums with even the minimum maturity needed precooling to retard color development and that forced air circulation and salting in transit was no substitute for it. Last year's tests likewise showed that Santa Rosa plums of minimum maturity required thorough precooling.

The riper test fruit, maturity 5, (80 to 85 percent pink to red) arrived too ripe in all three cars. Even the bottom layers were too warm for it. From the standpoint of appearance and quality this fruit was slightly better than the minimum maturity, both being rated good to excellent.

Test car 8:

The first Santa Rosa test from the Reedley district was on June 16 in a fan car, Hoak load, precooled for about 9 hours to 48°, shipped standard refrigeration with 3 percent salt. The temperatures encountered in this car were favorably low with the exception of the middle layer quarter length, which cooled slowly. The top doorway position averaged 44°F., the top quarter length and bunker 40°, the middle quarter length 46°, and the bottom doorway and bottom quarter length 38° and 40° respectively.

The test crates of commercial pack had about 45 percent pink to red color when they were packed and upon arrival were 85 percent pink to red at the top doorway position and in an excellent stage of ripeness for the wholesaler; at the top bunker the plums were slightly green and in the cool bottom layers (bunker and doorway) they were too green for best wholesaling.

Fruit of minimum maturity was a little too green on arrival after shipment at the top quarter length position, having about 45 percent red color but that from the middle quarterlength where it was somewhat slower in cooling had 60 percent overcolor and was excellent for auction display.

The riper fruit, maturity 5 (80 to 85 percent red when packed), arrived with too much color at the middle quarter length; but that shipped in cooler parts of the load, top and bottom quarter length, although showing 95 percent overcolor on arrival, was firm and in good condition for the wholesaler.

Test cars 9, 10 and 11:

Three test cars of Santa Rosa plums were loaded at Reedley on June 22. Each was a standard car without fans. All were Hoak loads but they differed in the amounts of precooling they received. Car 9 was precooled only 8 hours to a final temperature of 57°, car 10 was precooled about twice as long to 48°, and car 11 was precooled 19½

hours to 43°. All were shipped standard refrigeration with car 11 receiving 3 percent salt in transit.

The lack of thorough precooling resulted in higher transit temperatures in car 9 than in other test cars. The transit temperatures averaged:

	Top doorway °F	Top quarter °F	Middle quarter °F	Bottom quarter °F	Bot. bkr. °F
Car 9, precooled to 57°,std.car	50	59	53	43	41
Car 10,precooled to 48°,std.car	46	52	52	42	37
Car 11,precooled to 43°,std.car	44	46	48	42	40

The condition of the plums on arrival in these three cars affords a comparison of the effects of various amounts of precooling. The greenest fruit shipped (maturity 3) had 30 to 40 percent pink to red color and was mostly hard. Some plums were so green that they were passed on equivalent maturity. Top, middle and bottom layers were too warm for these plums except in car 11 and in it the fruit ripened so much in transit that it was at the upper limit of acceptability on arrival. These tests showed that even the greenest fruit commonly packed for eastern shipment required thorough precooling for shipment in standard cars during warm weather.

More mature plums having 90 percent pink to red color when packed (maturity 5) arrived too ripe except in the bottom layers of cars 10 and 11. Thus the top layers of even well-cooled cars were too warm for the shipment of fairly firm plums showing 90 percent color when packed and unless the car was well cooled the bottom layers were also too warm. It should be pointed out that these were not fan cars.

Fruit of commercial pack, averaging 80 percent pink to red color when packed, arrived in good condition in all parts of well cooled car 11, but only the bottom layers of cars 9 and 10 were cold enough.

There was considerable complaint of overripe fruit after the auction on the day that this test arrived, Friday, July 3. This was due in part to the fact that fruit would have to be held until Monday for the retail markets because of the 4th of July holiday.

Test car 16:

Fruit of advanced maturity that had about 95 percent red color, 10 percent of which was dark red, was shipped in car 16 after a few days storage. It was a standard car shipped standard refrigeration after warehouse precooling to about 35°. The top layer quarter length averaged 50° and the bottom layer quarter length 41° for the trip. Both packages of test fruit at these positions contained too many dark red, soft plums on arrival. It was evident from this test that transit temperatures lower than 40° were needed for fruit of this maturity. Probably 35° or 36° would have been necessary since the

fruit was as highly colored as desired for the auction at the time it was packed.

Discussion - Santa Rosa Plums.

Market preference for Santa Rosa plums was not always the same. When supplies were light, riper fruit would be accepted than when they were plentiful, and buyers for local stores also wanted riper fruit than those who purchased plums for dealers some distance from New York. The usual preference was for fruit that had 50 to 90 percent pink to red color with no dark red or ripe plums in the pack. This was a little more color than was acceptable in 1941.

Santa Rosa plums of the minimum maturity that had 40 to 45 percent pink to red color when they were packed did not require low transit temperatures such as prevail in bottom layers, although such temperatures were not objectionable since there was little need for color development for the fruit to satisfy auction demand. Top layer temperatures in poorly refrigerated cars were too high; these plums required transit temperatures averaging less than 50° and this called for good precooling of standard cars or moderate precooling of fan cars (table 3). These results are very similar to those obtained last year with plums of this maturity.

Plums having 75 to 85 percent pink to red color (maturity 5), representing the ripest fruit packed for eastern shipment, generally required temperatures that averaged 40° to 45°, such as were encountered in bottom layers (table 3). This fruit had to be held in about the same condition as when packed for it had about all the red color the wholesale market wanted. The top layers of well precooled fan cars had low enough temperatures, but standard cars, even if well precooled, usually had part of the top layer too warm for this fruit. The best way to assure good arrival was to place it in bottom layers or else ship it in well precooled fan cars. The possibility of using dry ice to supplement the refrigeration of plums of this maturity is discussed elsewhere in the report. The flavor of these highly colored plums was the best of all maturities shipped, consequently some extra effort in refrigerating them so they will arrive in good condition is worthwhile. Last year fruit of this maturity was considered too highly colored on arrival when shipped in the bottom layers although several days were actually required to ripen it. This year, as indicated, much of this highly colored fruit was acceptable if it was firm and not dark red.

The commercial pack, consisting of an assortment of plums ranging from 30 to 40 percent red to almost full color, had a wide latitude of suitable transit temperatures (table 3). It usually arrived in good condition in the bottom layers of all cars and in other parts of well precooled fan cars where average temperatures were in the range of 37° to 44°. It was usually slightly ripe or too ripe after shipment in the top or middle layers of standard cars unless they were well precooled.

TRAGEDY PLUMS

Test car 16:

The first test with Tragedy plums was made July 2 from Exeter in a car shipped standard refrigeration and loaded with fruit that had been warehouse precooled to 35°. Temperatures in transit were only fair for a standard car, averaging for the top layer doorway 50°, top quarter length 47°, middle quarter 44°, bottom quarter 41° and bottom bunker 38°.

On arrival 11 days after loading, most of the commercial consignment of Tragedy plums in the car showed no green color but 50 percent blue color was in evidence with 15 to 25 percent of the plums ripe. The small fruit, 6x6's, were in good condition for the auction, but the larger fruit in the car was riper than the trade wished to handle. The degree of ripeness sought by the buyers at the time this car was sold was about 5 percent green color, the balance light blue with no dark blue in evidence.

Test crates of the commercial pack (about 75 percent blue) arrived full to dark blue and 10 percent ripe in the top layer doorway and were barely acceptable. Those shipped in the middle and bottom layers of the quarter length stack, where temperatures were 6° to 9° cooler, arrived in excellent condition.

The minimum maturity (40 percent blue and 60 percent green) arrived too green when shipped in the cool bottom layer, but other packages shipped in the top layer, at the doorway, arrived in excellent condition, showing 90 percent blue color. This fruit offered little difficulty in refrigeration and it had good flavor, almost as good as riper fruit with 95 percent blue color.

Plums of the ripest maturity packed for eastern shipment, having 95 percent blue color, 25 percent of which was dark blue when packed, arrived slightly ripe even when shipped in the cool bottom layer at the bunker.

Test car 17:

A second test with Tragedy plums was made from Lodi on July 11 in a fan car precooled 8 hours and shipped standard refrigeration, 2 percent salt at all icing stations and 400 pounds added when the car was loaded. Temperatures in this car were uniformly cool, reaching 40° within 2 to 4 days after loading and remaining at this temperature for the remainder of the trip. The top layer doorway averaged 45°, bottom bunker 43°, and bottom quarter 44°.

Test crates of commercially packed fruit (70 percent light blue to blue, 30 percent green) arrived showing a trace to 5 percent green color, all being at the best stage for wholesaling.

Greener fruit, representing the minimum maturity, having 40 percent light blue color with 25 percent of the plums passed on equi-

valent maturity when packed, arrived too green for best auction display even when shipped in the top layer. It ripened, however, with good flavor.

In this car, the ripest fruit packed for eastern shipment (maturity 5, having 90 percent blue color) arrived in satisfactory condition for wholesaling even when shipped in the top layer. This well refrigerated car proved to be satisfactory for the shipment of Tragedy plums showing 70 to 90 percent blue color, but it was slightly too cool for fruit only 40 percent blue.

Test car 19:

The third test with the Tragedy variety was made from Exeter on July 18. The fruit was warehouse precooled to a final temperature of about 45° and was shipped in a standard car under standard refrigeration, 2 percent salt to be added at 2 reicing stations in addition to 200 pounds added when the car was loaded. The fruit at the top doorway averaged 49° and that at the bottom bunker 37°.

Plums of minimum maturity (45 percent blue and 55 percent green when packed) were slightly ripe on arrival in the top layer doorway, and those shipped in the bottom layer bunker were too green for best auction display.

The top layer temperatures in this car proved to be too warm for the slightly riper fruit having about 65 percent blue color when packed, but similar plums shipped in the cool bottom layer arrived in good condition.

Discussion - Tragedy Plums

Plums of this variety most desirable to the auction trade were those showing about 80 to 95 percent blue color upon arrival with very little of the fruit dark blue and ripe.

These tests indicated that for shipment in standard cars without fans, plums having about 40 to 45 percent of their surface blue colored were at about the limit of ripeness for the top layers where average transit temperatures were 45° to 50° (table 4). Plums with 65 to 90 percent blue color could be shipped without overripeness in cooler portions of the load where average temperatures were 37° to 45°. In contrast to these results in standard cars, fruit with as much as 90 percent blue color arrived in good condition in top layers as well as bottom layers of fan car, precooled and shipped standard refrigeration under instructions for salting.

DUARTE PLUMS

Test car 18:

The first shipment of Duarte plums was made from Lodi on July 15 in a fan car of different design from those used in previous

tests (see table 1). The fruit was given a short precooling of 4½ hours to a final temperature of 64° and was then shipped standard refrigeration. This car had a fairly good record in spite of a poor precooling job. Top layer doorway averaged 47°, bottom layer bunker 42°, and top, middle, and bottom layers of quarterlength 43, 45, and 44° respectively. This car was in transit 13 days.

Fruit at all positions tested, representing the commercial pack consisting of a mixture of plums half to full light red, with flesh full pink to light red, arrived in excellent condition for the wholesaler with only a few dark red, ripe plums scattered through the pack.

Plums of minimum maturity (maturity 3) that had flesh ½ to 3/4 pink and skin color 50 to 75 percent light red were not well enough colored on arrival to satisfy the wholesale trade. This was true for those shipped in the top layer doorway as well as for the plums shipped in the cooler bottom layer of the bunker stack.

Fruit that was almost full red color when packed, with about 20 percent of it dark red (maturity 5), arrived slightly ripe in the bottom layer and it was definitely ripe in the top layer.

Test car 20:

The second Duarte test was shipped from Newcastle on July 18 in a standard car, Hoak load, with 2 reicings in transit after precooling 25 hours to 38°. The top layer doorway and quarterlength averaged 45°, middle quarter 43°, bottom quarter 41°, and bottom bunker 39°.

The commercial maturity had 25 percent or less light red to full red color, averaging about 70 percent. The flesh was mostly red to full red. The test packages of this fruit in the bottom, middle, and top layers of the quarterlength stack arrived in excellent condition for the wholesaler.

The least mature fruit (maturity 3) had about 45 percent red color with flesh 3/4 to full pink when it was packed, and upon arrival it was too green at either the top doorway or bottom bunker positions.

Plums with 70 percent light red color with flesh mostly full red when packed arrived too ripe in the top layer doorway stack.

Test car 21:

Another standard car, Hoak load, precooled to 42° was shipped July 23 from Newcastle. It received 2 reicings in transit. Despite long precooling, the load was not very cool in transit, as the average transit temperatures indicate. They were: top layer quarter length 49°, top doorway 46°, middle quarter length 47°, bottom quarter 43°, and bottom bunker 39°.

Test packages of the commercial pack arrived in good condi-

tion for the auction in the top, middle and bottom layers. These plums were 50 to 75 percent light red, averaging about 60 percent when they were packed. Their flesh was 1/2 to full light red.

The greenest fruit (maturity 3) in the top layer of the doorway stack arrived in good condition for the auction, showing about 80 percent pink to red, with no plums dark red or ripe. Such fruit was too green upon arrival when shipped in the bottom layer, bunker stack.

The other extreme, the ripest fruit selected for eastern shipment, possessing about 90 percent red color, was too ripe after shipment in the top layer, but that from the bottom layer, bunker stack arrived in excellent condition for the auction showing about 95 percent red with none of the plums ripe.

Discussion - Duarte Plums

The auction trade preferred Duarte plums showing 75 to 90 percent red color, but they did not want many dark red plums or fruit that was not firm. The buyers also preferred fruit with pink to red flesh color.

The commercial pack of Duarte plums was probably a little more uniform in maturity than was the case with Beauty and Santa Rosa. Most of the commercial packs had an average of about 75 percent light red color, varying from 50 percent to full color. This proved to be a desirable maturity for eastern shipment in all of the test cars, for it arrived in good condition in all parts of the loads (table 5).

Plums having about 50 percent light red color when packed (minimum maturity) arrived in many shipments greener than the auction preferred. This fruit developed good quality but it was not equal to more highly colored fruit. This is an indication that fruit greener than this, for instance, equivalent maturity, should not be shipped.

The ripest fruit shipped showing 90 percent red color, needed bottom layer temperatures except in a well cooled fan car. Treatment with dry ice in addition to thorough precooling, discussed in another part of the report, is suggested as an aid to shipping such plums.

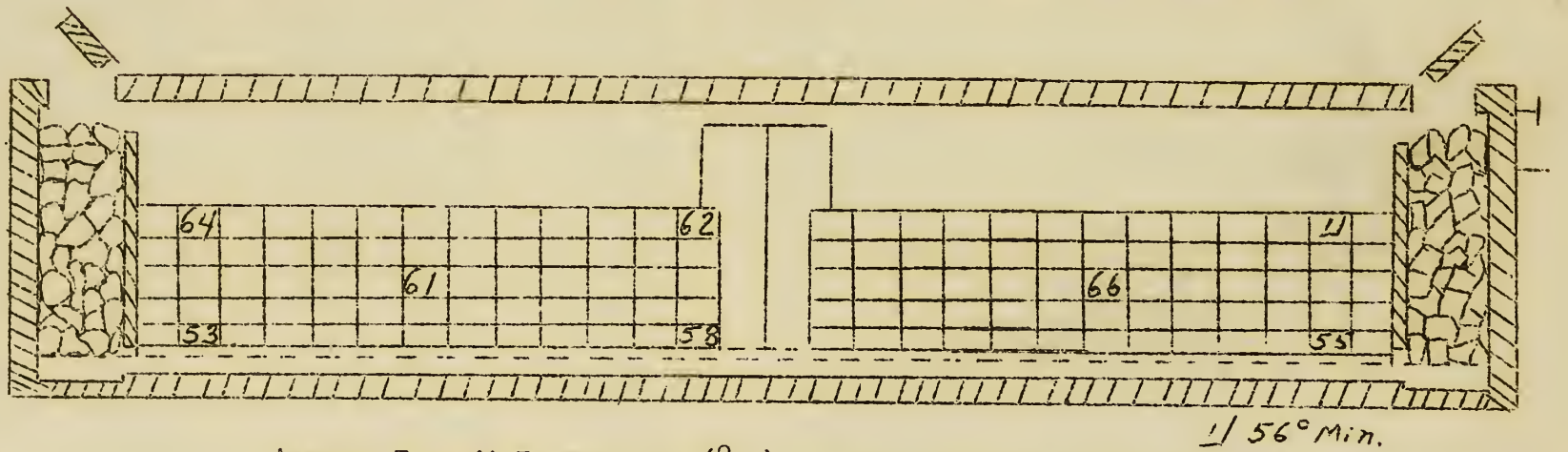
PRESIDENT PLUMS

Test cars 24 and 25:

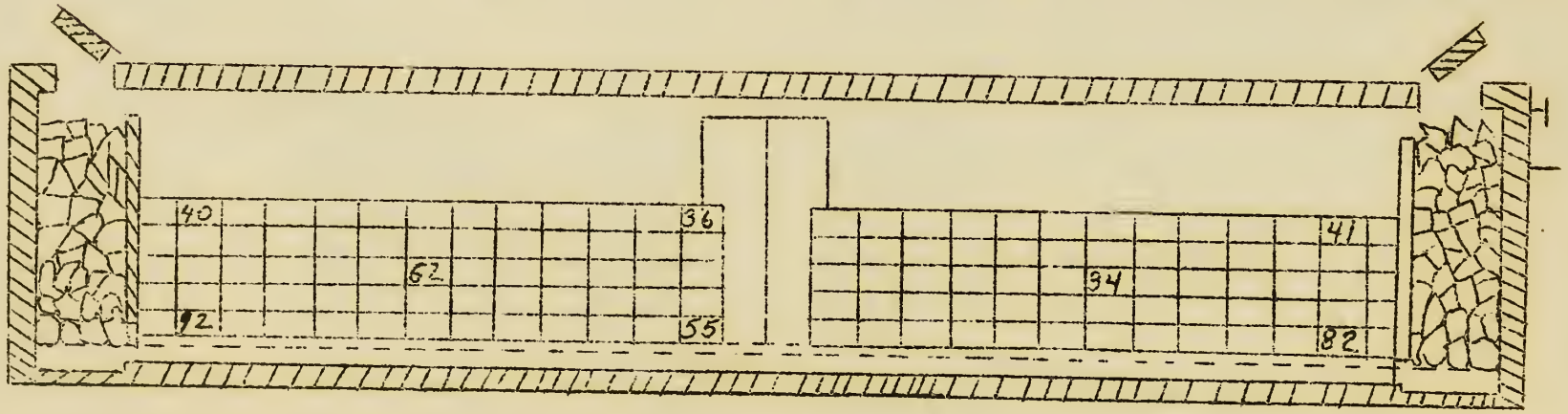
Two test cars of President plums were shipped from Lodi on August 7, one of which was a standard car (car 24) precooled for 10 hours to 42° and the other a fan car (car 25) not precooled, with 78° average temperature when shipped. Both cars were shipped standard refrigeration, 2 percent salt, and the nonprecooled fan car received 400 pounds of salt at the shipping point. The transit temperatures encountered in these cars are shown in figure 3. The average transit temperatures were as follows:

Fig. 7 - Average Tomato Temperatures of Test Car 17 in Transit; Brentwood, California to Boston, Massachusetts, October 1 - 14, 1942. Initially Iced at Brentwood After Loading, Not Reiced, One Vent Open at Each End to Ogden, Standard Ventilation Beyond

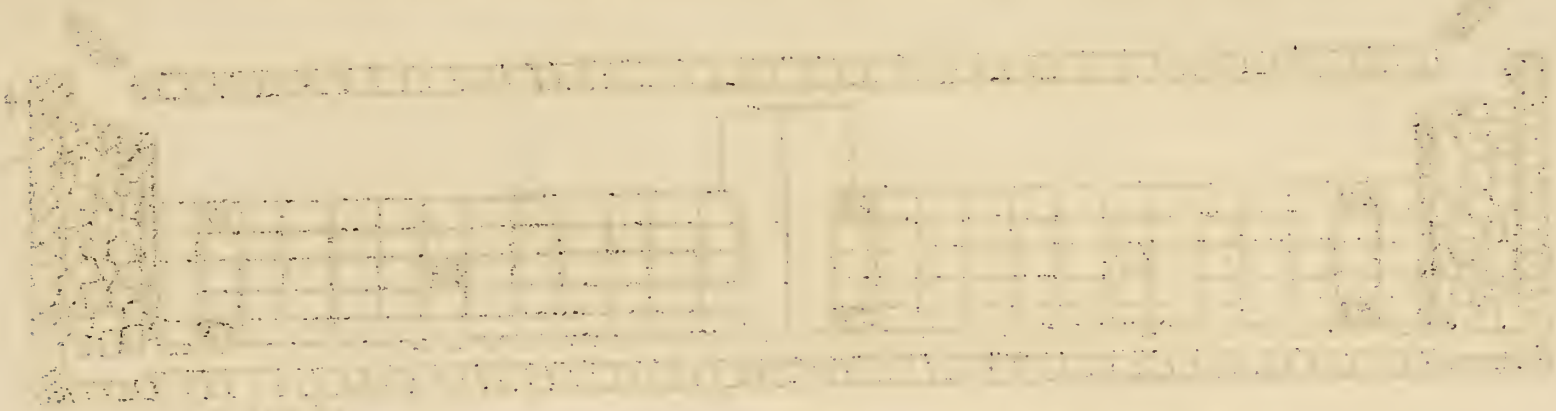
Tomato Lugs in Railway Refrigerator: Longitudinal Section near Centerline.

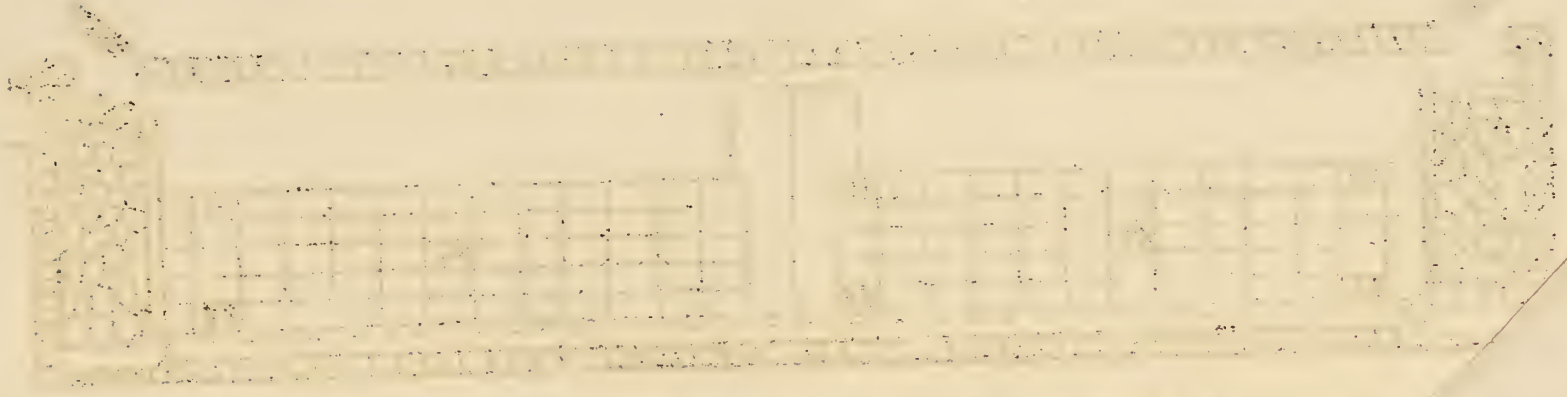


Average Transit Temperature (°F.) of Various Parts of the Load.



Percentage of Green Tomatoes in Various Parts of the Load On Arrival At Boston.





	Top quarter °F	Middle quarter °F	Bottom quarter °F
Car 24, standard car, precooled	47	46	39
Car 25, fan car, not precooled	43	46	42

President plums of two maturities were shipped in each car. One lot consisted of the greenest fruit in the packing house (maturity 3) and these barely met the minimum maturity requirements of this variety. These plums had 75 percent light reddish purple color with the balance of the color yellowish green and greenish yellow. The fruit was hard (11 pounds pressure test) and had 14.8 percent soluble solids. This fruit was too green for best auction display on arrival in the top layer of the fan car but in the standard car, which had 4° higher temperature, it arrived in excellent condition for the auction. Bottom layer temperatures were too cold for this fruit in both cars. The plums had good quality when ripe but they were not as good or as attractive as the riper fruit shipped in these cars.

Plums of more advanced maturity (maturity 5) had 95 percent blue color, a pressure test of 9.4 pounds, and soluble solids of 17.4 percent when they were harvested. These plums arrived in good condition in the fan car in both the bottom and top layers but those shipped in the top layer of the standard car were fully colored and were considered to be slightly past the best condition for the auction although 4 days were required to ripen them.

Test car 26:

A third shipment of President plums was made from the Loomis district August 14 in a standard car precooled for about 17 hours to 38°. It was shipped standard refrigeration, 3 percent salt. Top layer quarter length had an average temperature of 49° and the bottom layer 39°.

The maturities used for test crates were the greenest and ripest fruit packed. The least mature fruit (maturity 3) had 75 percent purplish red color and was mostly hard and proved to be slightly too green on arrival when shipped in either the top or bottom layer of the car. On arrival the full colored, riper fruit (maturity 6) was slightly past the best condition for the wholesale trade in the top layer but that shipped in the bottom layer was in good condition.

Test car 27:

A final test was made with President plums on August 18 from Lodi. This shipment was in a fan car, nonprecooled load, shipped standard refrigeration with 2 percent salt in transit. The average transit temperature was 43° for the top and bottom layers and 45° for the middle quarter length.

Test crates of commercial pack consisted of plums with about 90 percent blue color when shipped, about half hard and half firm.

They arrived in good condition for the wholesale trade even after shipment in the middle layer where temperatures were relatively warm. Their flavor was excellent when they were ripe.

No fruit of minimum maturity was packed this late in the season and the greenest fruit had 85 percent reddish purple color (maturity 4). This fruit was in very satisfactory condition for the auction on arrival, after shipment in both the top and bottom layers. Both lots were about alike; they were firm and had about 80 percent blue color and 10 percent light blue. The fruit had good flavor when ripe.

Fruit riper than this lot, having 95 percent full purple color when packed, also arrived in good condition in top and bottom layers of this car. Although the plums shipped in the top layer were fully colored on arrival, they were firm and not overripe. Those from the bottom layer had a little less blue color. This fruit rated excellent in flavor when ripe, but some plums were somewhat dry and mealy.

Discussion - President Plums

The market preference for this variety was for fruit showing full blue color with little dark blue or soft fruit in evidence. Plums with only 85 percent blue color on arrival were considered slightly green for best auction demand.

These tests indicated that fruit of the minimum maturity, that is having 75 percent of the surface reddish purple color and the ground color light yellowish green, generally arrived slightly green even when exposed to fairly high transit temperatures. Fruit only slightly riper, showing 85 percent reddish purple, was more desirable without offering any refrigeration difficulties. Even fully colored fruit arrived in good condition with little overripeness in any of the shipments (table 6). This variety is apparently slow in ripening and can be shipped when fully colored if the plums are not dark blue or soft.

CARBON DIOXIDE TESTS

Experimental work by other investigators 1/ on the storage of plums in atmospheres modified with various concentrations of carbon dioxide has shown that the development of color and softening was retarded without injurious effects to flavor and ripening response as long as certain limits of concentrations and exposures were not exceeded. Recent work on the use of dry ice to supplement the transit refrigeration indicated that concentrations could be held high enough in refrigerator cars to be of benefit and not too high to damage plums if

1/Ryall, A.L., A.S.H.S. 32, p. 164-169, 1934. Allen, F.W., A.S.H.S. 37, pp.467-472, 1939. Allen, F. W. and Smock, R.M., A.S.H.S. 35, pp. 193-199, 1937. Brooks, et al, U.S.D.A. Tech. Bull. 318, 1932. Brooks, et al, U.S.D.A. Tech.Bull. 519, 1936.

a large charge of dry ice (about 1,000 pounds) was applied in double-wrapped 50 pound cakes so that sublimation would be slow 2/. About 100 pounds were broken on the water ice to build up concentrations quickly. This method was followed in the test shipments of plums. It was found that three to four hours after applying the dry ice, a gas concentration of 15 to 20 percent was obtained inside the car. This concentration probably decreased to 10 to 15 percent during the first day the car was rolling. No provision was made to determine gas concentrations in transit, but in one instance an analysis of the atmosphere in the car upon arrival in New York the 12th morning showed 2.5 percent CO_2. No dry ice remained, but frost on the wrappers indicated that it had lasted throughout most of the transit period.

As used in these tests, the addition of 1,100 pounds of dry ice to a load of fruit moving under standard refrigeration had little effect in lowering the transit temperature of the fruit. This is shown by the following data taken from the Ryan recording tapes.

Test	Refrigeration	Average Fruit Temperatures in Load		
		Top Quarter	Middle Quarter	Bottom Quarter
12	Standard	46	42	38
13	Standard + dry ice	43	43	38
14	Standard	51	49	41
15	Standard + dry ice	46	45	37
22	Standard + dry ice	55	53	44
23	Standard	49	48	41

The shipping tests were supplemented by tests at Davis in which the plums were stored for the 10-day transit period at 42° in air and in chambers to which sufficient dry ice had been added to give carbon dioxide concentrations of 5 and of 10 percent. For comparison, part of each fruit sample was held in air at 32°F. Following this simulated transit period, all samples were held at room temperature for ripening.

RESULTS OF TESTS WITH CARBON DIOXIDE

Beauty Plums

Holding tests

The Beauty plums used in the holding tests were harvested from the University Farm orchards June 19, 1942, and were carefully sorted into four color groups approximately as follows:

2/ Ryall, A. Lloyd, et al, U. S. D. A. H. T. & S. Report 76, 1941. Gerhardt, et al, U. S. D. A. H. T. & S. Report 51, 1941.

Lot No.	Maturity	Ground Color	Pct.	Max. Overcolor	Pct.
1	4	Lt. grn. to yel. grn.	90	Light red	10
2	4½	Yellow green	75	Light red	25
3	5	Green yellow	50	Red	50
4	Com. Ripe	Yellow	0-25	Red	75-100

One basket of each maturity was immediately stored in the atmospheres and at the temperatures stated above.

MATURITY 4 (10 Percent Color)

After holding for 10 days in 42° air, Beauty plums that were harvested with 10 percent pink or red color showed approximately 45 percent light red with 25 percent of the ground color yellow. They were all classed as firm. Baskets of comparable fruit held at the same temperature in an atmosphere containing CO_2 showed 25 to 35 percent red color and only 10 percent yellow ground color. Nearly half of the fruit was still classed as hard. In appearance this fruit held in CO_2 at 42° was almost identical with the control samples which had been held in 32° air. In texture it was even more firm.

Twenty-four hours after removal to room temperature, the difference in color and firmness between the fruit held at 42° in air and in CO_2 was more marked than when the test lots were removed from storage.

After removal from transit temperatures to room temperature the number of days required before the fruit was considered in prime eating condition was as follows:

Held at 42°, in air -- 2 days
Held at 42°, in 5 percent CO_2 -- 3 days
Held at 42°, in 10 percent CO_2 -- 4 to 5 days
Held at 32°, in air -- 3 to 4 days

Dessert quality in the fruit held for ten days in 10 percent CO_2 was perhaps slightly inferior to that held continuously in air. All samples were in poor market condition the second or third day following the attainment of optimum ripeness for eating.

MATURITY 4½ (25 Percent Color)

Plums harvested with 25 percent color showed the same relative differences as were secured with fruit of 0 to 10 percent color. "On arrival" the fruit carried in carbon dioxide atmospheres was approximately 50 percent red colored as compared to 75 percent for that held in 42° air. All of the latter were considered "firm ripe". Both lots of fruit were too far advanced for the wholesale trade.

Color differences were again more marked one or two days after arrival. The number of days required for the different lots of fruit to reach prime eating condition were in all instances one day less than for the different lots picked with a maximum of 10 percent color.

A concentration of 10 percent carbon dioxide had no detrimental effect upon the dessert quality of Beauty plums harvested with 25 percent color.

MATURITY 5 and COMMERCIALLY RIPE

Riper fruit (picked 50 percent to full color) again showed the effects of the CO_2, but with more color development and softening before picking differences between the lots were often less noticeable. After the transit period all lots were too ripe for auction demand. Fruit harvested with 50 percent color was in prime eating condition in from one to four days. Fruit of 75 percent to full color when harvested was either eating ripe upon arrival (42° air sample) or on the following day. Approximately half the fruit carried in 10 percent CO_2 remained in fair retail condition for four days, or twice as long as the fruit held continuously in air.

Shipping tests:

In tests 12 and 13 from Newcastle, June 26, two comparable cars of Beauty plums were shipped under standard refrigeration. In test 13, 1,100 pounds of dry ice was added. Test packages of maturity 5 (fruit averaging 45 percent color) and commercial maturity (also averaging 45 percent color) were placed quarter way of the load in the top, center and bottom layers. Commercial test crates of "ripe" fruit (averaging 80 percent color) were also included at the center position in each load.

The two cars were not unloaded until the twelfth morning, being held in Jersey City for two extra days.

At time of unloading a comparison was first made of the commercial part of the two cars. The plums in the gassed car showed about 15 percent less red, and considerably less yellow ground color than those in the car receiving no gas. This was sufficiently marked to cause comment from the receiver. After twelve days in transit all Beauty plums of maturity 5 were too far advanced for the auction except those at the bottom layer position of the gassed car.

Commercially ripe plums, shipped at the middle quarter length position, were 100 percent ripe in the untreated car and those in the gassed car were only 10 percent ripe. This difference brings out the influence of carbon dioxide upon ripening, although with the rather low concentration of the gas maintained in the car and the advanced stage that the fruit was in when shipped even that shipped in the carbon dioxide cars were too ripe on arrival.

SANTA ROSA PLUMS

Holding tests:

As with the Beauty variety, Santa Rosa plums of maturity 3 (20 to 40 percent color) and of maturity 4 to 5 (75 to 100 percent color) were likewise harvested from the University Farm orchards July 3 and held in air and in CO_2 for the shipping period.

After ten days, fruit of maturity 3 held in 42° air was 50 percent pink or light red with a greenish-yellow to yellow ground color. Fruit held in 5 percent CO_2 was of equal red color, but showed less yellow; that held in 10 percent CO_2 was greenish-yellow and only 40 percent pink or red. It was very similar in appearance to fruit which had been held in 32° air.

After the transit period the fruit was observed daily for changes in color and firmness. Fruit held for ten days in 42° air required 5 days at 75° to become ripe, that held in 5 and 10 percent carbon dioxide, 6 to 8 days and 7 to 9 days, respectively. Carbon dioxide delayed ripening of the greener fruits somewhat too long and the dessert quality was slightly impaired.

Plums harvested with practically full color were held at 42° for 10 days with only slight color change and at first glance, little difference appeared in the lots. However, the red color and also the straw ground color was slightly more advanced in the sample held in air than in the CO_2 lots.

After four days at room temperature the following conditions were noted:

42° air -- fruit nearly black and soft
32° air -- dark red and full ripe
42° 5 percent CO_2 -- dark red, one-half ripe
42° 10 percent CO_2-- mostly medium red, not ripe

Most of the fruit held at 42° in air was overripe after two additional days, whereas only about 50 percent of the fruit held in 10 percent CO_2 was ready for eating. The fruit held in 5 percent CO_2 and in air at 32° was similar and intermediate in ripening between the 42°-air and the 42°-10 percent CO_2 lots.

Holding tests with Santa Rosa, therefore, shows the potential value of carbon dioxide in making it possible to ship this variety with more color if and when a concentration between 10 and 5 percent of CO_2 can be maintained in the refrigerator car during the 10-day transit period. As with the Beauty variety, fruit of minimum maturity may have ripening retarded to such an extent that it will fail to develop optimum color or texture.

Shipping tests:

Tests 14 and 15 were made in two Hoak loads of fruit from Reedley, June 30. In test 15 where dry ice was used the fruit was precooled only to an average temperature of 51° and was shipped standard refrigeration with 3 percent salt at each reicing. In test 14, the fruit was precooled to 43° and shipped standard refrigeration (without salt). Probably as a result of the salt applied in transit, the temperature in the dry ice car after the first two days averaged 3° to 5° colder than in the car without the dry ice.

In each car, test crates of Santa Rosas of maturity 5 (averaging 90 percent color) and crates commercially packed (averaging 80 percent color) were placed at the top, center and bottom quarter length positions. One crate of maturity 3 (meeting only the minimum requirement of 45 percent color) was placed at the middle quarter position of each load.

Upon arrival the ripest fruit shipped (maturity 5) was too far advanced at all quarter length positions of the ungassed car. In the gassed car the fruit at the center quarter length position was likewise considerably overripe. Fruit in the top of the load was slightly ripe; in the bottom, however, there was no ripe fruit upon arrival.

Fruit in the commercial test crates at the top quarter length of the gassed car and at the top and middle position of the ungassed car was likewise considered overripe for the auction. The middle and bottom layer fruit in the gassed car and the bottom layer fruit in the standard car was satisfactory for the wholesaler.

Maturity 3 (45 percent color) after shipment in the middle layer at the quarter length, the warmest position in the car, was 70 percent colored and it was in satisfactory condition for the wholesaler although the fruit in the standard car was on the ripe side.

An inspection of the different commercial lines from the two cars on the auction pier showed that the plums which were treated with carbon dioxide had at least 20 percent less color than those shipped in the untreated car. The gassed fruit averaged 75 to 80 percent color with a few dark plums but no ripe fruit. It was reported as being in excellent condition for the wholesale trade. In the other car, all the fruit was of full color with 25 percent dark red and at least 6 percent ripe. The car was considered well past the proper stage for the wholesaler.

TRAGEDY PLUMS

Shipping tests:

No holding test was made of Tragedy plums but this variety comprised the bulk of the load in test cars 22 and 23 shipped from Lodi, July 22.

Tragedy fruit of both maturity 4 (averaging 55 percent color) and maturity 5 (averaging 95 percent color) were shipped. Test crates of maturity 4 were at top, center and bottom quarter positions, whereas the test crates of maturity 5 were omitted from the top position.

After 23 hours precooling, the average fruit temperature in this car was 48°; that of the companion car (test 23) to which no dry ice was added before shipment was 42°. Both cars moved under standard refrigeration, and this initial difference of 6° higher temperature in the dry iced car persisted in the top layer throughout the transit period. In fact, during the first day in transit, the difference in temperature was as much as 10°F.

Upon arrival no marked or consistent differences appeared in the coloring and softening of the fruit in the two cars; the more thorough precooling received by the untreated car apparently offset the effect of the dry ice.

Fruit of maturity 5, even when carried at the bottom and middle quarter position, arrived too far advanced for the auction. Fifteen to 20 percent of the fruit was dark colored and ripe.

Fruit of maturity 4, harvested with approximately one-half color, was likewise almost too ripe for auction and that at the top quarter position was even riper, one-third of the fruit being of dark color and from 30 to 45 percent ripe. This is not believed to have been due to over-maturity at time of shipment but to the fact that the cars were fairly warm throughout the entire transit period. The top layers had a temperature of 50° to 54°F. Plums of this maturity in the bottom layer were mostly in good condition.

DUARTE PLUMS

Holding tests:

Carbon dioxide holding tests were made with Duarte plums (maturities 4 and 5 averaging 45 and 90 percent external color with 75 to 100 percent pink and 100 percent of the flesh red, respectively) from the same lots selected for shipping test 20, July 17, 1942, from Newcastle.

After the 10-day holding period the fruit of both maturities stored in 42° air had more color and was softer than the fruit held in CO_2. The samples held in 10 percent CO_2 were similar in color to the sample held in 32° air, little change having occurred.

After four days exposure to 75°, fruit of maturity 4 which previously had been in 42° air was in prime eating condition. Fruit held in CO_2 was still greenish-red and required two to three additional days to become ripe. Samples held in 5 percent carbon dioxide as well as those in 10 percent were slightly greener, more firm, and required longer to ripen than the sample held in 32° air.

The same relative differences were observed in the fruit harvested with nearly full color, but in all cases this fruit ripened 1 to 2 days sooner.

Fruit of maturity 4 held in carbon dioxide was perhaps of slightly lower dessert quality than that held continuously in air, but with the riper fruit, maturity 5, no difference was noticeable.

Shipping test:

The CO_2 shipping test with Duarte plums was combined with the Tragedy test from Lodi (test 22) July 22, and the same conditions and transit temperatures prevailed; that is, the car treated with "dry ice" was about 6° warmer than the companion car. Fruit of maturity 4 was used and the test crates were placed at the top quarter length position.

As with the Tragedy variety, when the test crates from the two cars were observed upon arrival in New York, it was difficult to see any difference between them, the lots in both cars having about 12 percent dark red plums. Thus again, precooling to about 6° to 8° cooler temperature offset the effect of the carbon dioxide.

WICKSON PLUMS

Holding tests:

No shipping test was made with this variety, but fruit was harvested from the University Farm orchard August 5 and held at Davis. When harvested, the plums were showing approximately 30 percent straw color with 70 percent greenish-yellow to yellowish-green. The flesh was "cream" color.

After the holding period, the fruit held at 42° in air was mostly straw color and firm ripe to ripe; that held in 10 percent CO_2 was 50 percent straw color and 90 percent firm. The firmness equaled that of the 32° fruit, but the color was slightly more advanced.

After two days at 70°, the fruit from 42° air was predominantly yellow, ripe, and relatively soft; the 10 percent CO_2 sample was in approximately the same condition as the air sample two days previous, and at this time was more firm and had slightly less color than the 32° air sample. Neither sample was ready to eat.

After two additional days at 70° the difference just mentioned between the fruit held in CO_2 and that held in air at 32° was more marked. Plums which had been held at 32° ripened rather uniformly, about 1/3 of the fruits showing red color. The sample from CO_2 storage was uniformly greenish-yellow to yellow. In appearance it was ripe but the flesh was still firm and lacked juiciness. Fruit carried in air at 42° was golden yellow to red, soft, juicy and slightly past prime.

Final observation on the above samples was made after holding six days at 70°. The fruit held in air at 42° was overripe and that held at 32° was half red and half yellowish-red and was soft and ripe to slightly overripe.

Fruit held in 10 percent CO_2 was still greenish yellow to yellow, and had rather tough, dry flesh. This concentration of carbon dioxide had apparently retarded ripening to such an extent that it could not proceed in a normal manner. The dessert quality of the fruit was definitely poor and the fruit was becoming infected with brown rot.

DISCUSSION - CARBON DIOXIDE TESTS

The holding tests confirmed previous results in showing that carbon dioxide definitely retarded both coloring and softening compared to that which normally occurs in air. Fruit held for ten days at 42° in 10 percent CO_2 was similar in appearance and condition to that held in air at 32°. It also remained marketable about two days longer. Fruit held for ten days in a 5 percent concentration remained good for at least one day longer than that held in air. Carbon dioxide thus had a residual effect even after the fruit was removed to normal air for ripening.

An atmosphere of carbon dioxide averaging as high as 10 percent during the normal ten-day transit period had no detrimental effect upon normal ripening or dessert quality in plums of advanced maturity with the exception of the Wickson variety. With fruit showing little more than the minimum maturity for shipping, normal ripening was so delayed that the quality was frequently impaired. This effect was noticed in the shipping tests as well.

In the shipping test, a charge of 1,100 pounds of dry ice had about the same retarding effect on ripening as 6° to 8° lower precooling temperature. This effect was less than observed in the holding tests where 10 percent CO_2 for 10 days was equivalent to lowering the temperature 10°, from 42° to 32°. It is doubtful if concentrations as high as 10 percent were maintained in transit for tests with cherries have shown that the concentrations ranged between 3.5 and 9.0 percent at the end of 5 days and upon arrival were only 1.0 to 2.0 percent 1/. In a fan car the concentration diminished even faster 2/. This season's tests indicate that dry ice would be helpful in the shipment of ripe plums. For maximum benefit such fruit should also be well precooled. The addition of dry ice, however, will compensate for some lack of cooling.

1/Gerhardt, Fisk, et al - A study of CO_2 gas retention in refrigerator cars during the commercial freight shipments of sweet cherries. U.S.D.A. H.T. & S. Report 75, 1941.

2/Smith, Edwin, et al - Report on a transportation test with sweet cherries in refrigerator cars; - Influence of the height of load, mechanical circulation of air and the use of CO_2 as a supplement to standard refrigeration.

FAN CARS AS A SUBSTITUTE FOR PRECOOLING

The transit temperature studies have shown that air circulation in transit such as is provided in fan cars will not usually take the place of thorough precooling.

The reason for this is brought out clearly in figure 1, where temperature charts from fan cars are presented. Cooling of the nonprecooled fan car was slow in transit despite salting of the ice as far as Chicago, and the temperature of the top layer at the doorway did not reach 43° until the end of the 4th day. The entire load of plums could have been precooled to this temperature in 24 hours.

The time required for a fan car to cool the load in transit to a temperature equal to that of a well precooled standard car is brought out in figure 2. Car 6 was a standard car, well precooled, shipped with 2 reicings in transit. The top layer was 43° at time of shipping. Car 7, a fan car, was precooled for only a short time and its temperature was 73° at this position when it was shipped. It received the benefit of 2 percent salt at all icing stations and shipment by standard refrigeration. The fan car reached the temperature of the standard car in 4 days; from then until arrival it had temperatures 3° to 5° lower but the average temperature for the trip was about 2° higher than in the standard car and the fruit in it was noticeably riper on arrival.

If a fan car gets a fairly long, fast run without long stops, cooling may be fast enough and transit temperatures low enough to compensate for no precooling. Such a condition was enountered from one loading point in a nonprecooled fan car shipped standard refrigeration with 2 percent salt (car 25, figure 3). Its companion car was precooled for 23 hours, and the top layer, quarter length, was about 38° when it was shipped. The nonprecooled fan car was cooled to the temperature of the precooled standard car 3 days after loading and during the remainder of the trip it was unusaully low in temperature, 36° to 37° for the most part. Because of this it had an average transit temperature $3\frac{1}{2}$° lower than the precooled standard car. Transit temperatures as low as these are not often obtained and a record as good as this cannot be counted on.

There might be some question concerning the value of an average temperature in comparing the effect of two different transit temperatures on the ripening of plums. There are obvious limitations in such methods of handling temperature data. Plums might be held at a high temperature for a day or two causing them to ripen, and then they could be held at an extremely low temperature but the damage would already be done, although the average temperature for the entire period might be as low as one that would stop ripening. Nevertheless, in the tests of 1941 and 1942, the averages for the transit period have proved to be sueful in analysing the test data. The color photographs and inspection records of the fruit have usually borne out the assumption that appreciable differences in average transit temperatures would be reflected in the condition of the fruit.

TEMPERATURE OF DIFFERENT PARTS OF THE LOAD IN TRANSIT

A carload of fruit does not have a uniform temperature in transit as the records taken in these studies and others have shown. This had led to the recommendation that the cool parts of the load be used for the ripest fruit and the warm upper layers for greener fruit. Drawings of plum loads with average transit temperatures indicated are presented in figures 4 and 5. The value of precooling in making loads more uniform in temperatures is brought out by comparing cars 9 and 11 in figure 4 (Hoak loads). A 16° spread in temperature existed between bottom and top layers of the quarter length stack in poorly precooled car 9, whereas in well cooled car 11 the spread was only 4°. The average temperature of the middle layer quarter length is not generally as warm in standard cars as that of the top layer. In this car it was slightly warmer because it was very slow in cooling, a fault common with this part of Hoak loads. It should be noted that fan car 8 maintained cool top layers, especially at the quarter length and bunker stacks. Other parts of the load were not much cooler than in the well cooled standard car (car 11), but it is evident that air circulation in transit made up for about 5° difference in precooling temperature.

Temperatures in standard lengthwise loads are shown in figure 5. Very uniform cool temperatures were obtained by a combination of good precooling and air circulation in transit (car 5). Fan car 18, precooled to only 64°, had a better transit temperature record than standard car 6, precooled to 47°. These tests show that air circulation in transit is beneficial in cars that have received limited precooling.

The main thing brought out, in respect to determining where to put ripe fruit, is that the bottom layer is the cool part of the load and in fan cars the top layer is also usually cool. The middle layers may be relatively warm in Hoak loads even in fan cars.

PRECOOLING

Hoak versus lengthwise loads:

The precooling of the vertical strip or Hoak load was given special attention since this load was used by many shippers to reduce breakage in transit. There were two reasons for expecting it to cool more slowly than the lengthwise load. First, in common with all crosswise loads, the end of the crate instead of its side is towards the air channel between rows and, since the end is thicker and tighter than the side, heat transfer through it would be slower. In addition, the vertical strips of the Hoak load prevent lengthwise movement of air. In these tests with the Hoak loads, several other difficulties were encountered.

The practice of covering the load with canvas near the door to prevent short circuiting of air in loads cooled by air blown into the car at the doorway had to be discontinued because with the air

channels blocked, little air from the precooler could reach the packages beneath the canvas. With all types of equipment it was hard to cool the middle layer, especially in the quarter length stack. This can be seen by comparing figures 6 and 7, records of Hoak and lengthwise loads respectively. In almost every test, the Hoak load showed a wide spread in the cooling rates of top and middle layers. Car 6 was cooled long enough to get the middle layer fairly cool but there were many cars that were not cooled this long in which middle layers were still quite warm after precooling. About 25 percent more time was required to cool this portion of Hoak loads as compared to lengthwise loads.

The top layers actually cool faster in Hoak than in lengthwise loads for the air blast can usually be held at a lower temperature since heat is not being removed as fast from the bulk of the load. Consequently, the average of all layers may cover up the true condition prevailing in the heart of the load. This is brought out by figure 8 which shows the cooling rates of crates of plums in the center of Hoak and lengthwise loads; that is, middle layer, quarter length stack. These cars were loaded at the same shed for this test and were cooled as nearly alike as possible. Differences were not great between averages of all layers or even the average of the middle layers, but when the centers of the loads were compared the Hoak load was warmer even though it had the lowest air blast. If the center of the load is warm after precooling, fruit here will ripen, and it will tend to warm the fruit in layers above it.

An attempt was made to improve the cooling of Hoak loads by suspending a canvas from the ceiling of the car to the top of the load on each side of the brace. The precooling equipment used in this test was bulkhead fans. It was thought that the canvas baffles would prevent the air from circulating around the load and would increase air movement down through the channels. Some benefit was obtained in faster cooling of the center of the load (figure 9) but not as much as was anticipated. The car with baffles, starting about 4° higher in temperature, reached the temperature of the other car in about 12 hours but showed no gain thereafter.

Precooling equipment:

The results of tests on thorough precooling of Hoak and lengthwise loads with the conventional type propeller fans are shown in figures 6 and 7. The precooling rates in a Hoak load precooled with Preco fans are shown in figure 10. This car was not precooled long enough for low temperatures and the middle layer was fairly warm at the end of cooling because of this, although the fans maintained fairly good cooling rates.

The results of a test with a trackside ammonia unit are shown in figure 11. The precooling period of only 8 hours was not long enough. About 18 to 24 hours were needed with this and other equipment to cool the load to the low 40's.

Cooling rates obtained in 1942:

The results of the precooling tests of 1942 were very similar to those obtained in 1941. There were instances when for short periods high rates were maintained, but for the thorough precooling that fairly ripe fruit needs, 18 to 24 hours were generally required and cooling rates of 1.3° to 2.1° per hour were about all that could be expected (table 7).

Amount of salt and ice used:

For good precooling, ice meltage per car varied from 7,700 to 11,600 pounds, the amount melted generally depending on how much heat was removed. Upon the basis of ice meltage, 2.7° to 4.3° were removed for every 1,000 pounds of ice consumed in these cars. Last year's values were in the same general range.

Estimating the temperature of the load:

Last year it was found that 5 easily accessible positions could be used to estimate the temperature of the load at the end of precooling. These were the bottom, middle and top layer crates of the doorway stack and those in the top layer of the quarter length and bunker stacks. In the 1942 tests, these positions were likewise reliable for lengthwise loads but not for Hoak loads (table 8).

SUMMARY

Tests on precooling and transit refrigeration of plums in relation to maturity and market quality which were begun in 1941 were continued in 1942. Twenty-seven test cars were shipped with Beauty, Santa Rosa, Tragedy, Duarte and President plums.

Beauty plums having 20 to 40 percent pink to red color on arrival were generally preferred by the auction. Early shipments were accepted without discount if showing 50 to 60 percent reddish color.

Plums of this variety having 10 to 15 percent pink color when shipped arrived in good condition in the bottom layers of all test cars and also in the top layers of well refrigerated fan cars. Average transit temperatures of 44° or less were apparently low enough for this maturity.

Fruit of minimum maturity, most of the plums greenish yellow, some with straw tips or trace of pink, needed transit temperatures that favored some color development such as were found in top and middle layers of moderately refrigerated cars. However, temperatures of 50° or above, encountered in top layers of poorly precooled standard cars, were too high and bottom layers of all cars which were in the range of 38° to 44° average temperatures were too cold. What was needed were temperatures averaging about 45° to 48°, obtained in top layers of well cooled standard cars or moderately cooled fan cars. Fruit possessing little greenish yellow, mostly yellowish green, was not good in flavor

and its shipment should be discouraged.

The usual auction preference for Santa Rosa plums was for fruit that had 50 to 90 percent pink to red color, with no dark red or ripe plums in evidence. This was a little more red color than was acceptable in 1941.

For plums of minimum maturity showing 40 to 45 percent pink to red color when packed, average transit temperatures cooler than 50° were needed and this called for good precooling of standard cars or moderate precooling of fan cars. Low transit temperatures such as prevail in bottom layers were not required but they were not objectionable since this fruit did not require much color development in transit to be acceptable by the auction.

Riper Santa Rosa plums, having 75 to 85 percent pink to red color generally needed temperatures that averaged 40 to 45° such as were obtained in the bottom layers of standard cars or the bottom or top layers of well precooled fan cars. These riper plums had the best flavor of all maturities shipped and were worth some extra effort in handling and shipping. (See also carbon dioxide tests.)

The commercial pack, consisting as it did of an assortment of plums ranging from 25 percent to full color and differing in maturity from time to time as riper or greener lots were packed, had a wide latitude of suitable temperatures. It usually arrived in good condition in the bottom layers of all cars and in other parts of well precooled fan cars where average temperatures were in the range of 37° to 44°. Top or middle layers of standard cars were slightly warm for this fruit unless well precooled.

Tragedy plums in best demand by the auction were those showing 80 to 95 percent blue color with very little dark blue or ripe fruit in evidence.

Plums having about 40 to 45 percent blue color when packed were about the limit of ripeness for top layers of standard cars where average transit temperatures were 45° to 50°. For cooler portions of the load in the range of 37° to 45°, plums having 65 to 90 percent blue color were satisfactory. In contrast with these results in standard cars, fruit with as much as 90 percent blue color arrived in good condition in top and bottom layers of a well precooled fan car shipped standard refrigeration with instructions for salting.

Duarte plums 75 to 90 percent red, with flesh pink to red were preferred by the auction. No dark red or soft fruit was wanted.

Commercial packs of Duarte plums appeared to be more uniform than those of other varieties and such fruit, varying from 50 percent to full color, averaging about 70 percent light red, arrived in good condition in all parts of the loads.

The barely passing maturity having about 50 percent light red when packed generally arrived with slightly less color than was desired. This is an indication that greener fruit, for instance equivalent maturity, should not be shipped.

The ripest fruit packed, which showed 90 percent red color, needed temperatures found in well cooled fan cars or in bottom layers of standard cars.

The market preference for the President variety was for plums showing full blue color with little dark blue or soft fruit in the pack. Plums showing only 85 percent blue color on arrival were considered slightly green for the auction.

Fruit of minimum maturity, having 75 percent reddish purple color, generally arrived slightly green even when exposed to fairly high transit temperatures; fruit with 85 percent overcolor was more attractive on arrival and gave no refrigeration difficulties. Even full colored plums arrived in good condition in most shipments. This variety is apparently slow in ripening and can be handled if fully colored if the plums are not dark blue or soft.

Atmospheres with 5 and 10 percent carbon dioxide at 42° retarded coloring and softening about as much as did storage at 10° lower temperature in air, these results confirming those of earlier tests.

In shipping tests, a similar retarding effect on ripening was observed from the addition of 1,100 pounds of dry ice to the car after it was loaded. In one test shipment it gave about as much control of ripening as did 6° to 8° lower precooling temperature. This treatment thus appears to have a place in the shipment of ripe plums but it is not recommended for fruit near the minimum maturity, for its ripening was delayed too much and it lost flavor.

It is usually necessary to precool fan cars if low transit temperatures are desired; a fan car may have as low transit temperatures as a standard car which is precooled considerably longer.

Top layer temperatures were reduced and more uniform temperatures were obtained throughout the load by thorough precooling. Fan cars which circulate air in transit also have more uniform temperatures than standard cars. The cool portion of the load in standard cars is the bottom and next to bottom layers; in fan cars, top and bottom layers are usually the coolest.

The middle layer of the Hoak load was hard to precool and in some tests required 25 percent more time to cool than this part of the lengthwise load.

With all types of equipment, thorough precooling to 40° or less requires 18 to 24 hours with air temperatures in the range of 32° to 40°.

ACKNOWLEDGMENTS

The cooperation of shipping firms, receivers, railroads, car companies and precooling agencies that made this work possible is gratefully acknowledged. To other coworkers thanks are due for assistance in making the tests.

TABLE 1
TEST SHIPMENTS OF PLUMS MADE IN 1942
INVESTIGATIONS

TEST NO.	LOAD	TRANSIT PERIOD	SHIPPING POINT	KIND 1/ OF CAR	VARIETY	HOURS PREC'LD	TEMP. 2/ WHEN SHIP'D °F.	REFRIGERATION 3/ IN TRANSIT
1	Lengthwise	6/2-12	Kern Co.	Fan	Beauty	4-1/2	57	Std. Ref. 3% salt first station
2	Lengthwise	6/2-12	Kern Co.	Fan	Beauty	none	78	Std. Ref. 2% salt to Chicago
3	Hoak	6/5-15	Reedley	Fan	Beauty	11-1/2	47	Std. ref. 3% salt
4	Hoak	6/8-18	Reedley	Std.	Beauty	6-1/4	55	Std. ref.
5	Lengthwise	6/12-22	Kern Co.	Fan	S. Rosa	21-3/4	43	2 reicings, 254-B
6	Lengthwise	6/12-23	Kern Co.	Std.	S. Rosa	18-1/4	47	2 reicings, 254-B
7	Lengthwise	6/12-22	Kern Co.	Fan	S. Rosa	4-1/4	70	Std. ref. 2% salt
8	Hoak	6/16-26	Reedley	Fan	S. Rosa Beauty	8-3/4	48	Std. ref. 3% salt
9	Hoak	6/22-7/2	Reedley	Std.	S. Rosa	8	57	Std. ref.
10	Hoak	6/23-7/3	Reedley	Std.	S. Rosa	15-3/4	48	Std. ref.
11	Hoak	6/23-7/3	Reedley	Std.	S. Rosa	19-1/2	43	Std. ref. 3% salt
12	Lengthwise	6/26-7/8	Newcastle	Std.	Beauty	19-3/4	35	Std. ref. 2% salt
13 4/	Lengthwise	6/26-7/8	Newcastle	Std.	Beauty	19-1/4	36	Std. ref. 2% salt
14	Hoak	6/30-7/9	Reedley	Std.	S. Rosa	10-3/4	43	Std. ref.
15 4/	Hoak	6/30-7/9	Reedley	Std.	S. Rosa	8	51	Std. ref. 3% salt
16	Lengthwise	7/2-13	Exeter	Std.	Tragedy	22	35	Std. ref.

(Cont'd)

TABLE 1 (CONT'D)
TEST SHIPMENTS OF PLUMS MADE IN 1942
INVESTIGATIONS

TEST NO.	LOAD	TRANSIT PERIOD	SHIPPING POINT	KIND 1/ OF CAR	VARIETY	HOURS PREC'LD	TEMP. 2/ WHEN SHIP'D °F.	REFRIGERATION 3/ IN TRANSIT
17	Lengthwise	7/11-21	Lodi	Fan	Tragedy	8	--	Std. ref. 2% salt, 400 lbs. added at loading point
18	Lengthwise	7/15-28	Lodi	Fan	Duarte	4-1/2	64	Std. ref.
19	Lengthwise	7/18-28	Exeter	Std.	Tragedy	22	45	Std. ref. 2% salt Waynoka and Corwith, 200 lbs. at loading
20	Hoak	7/18-28	Newcastle	Std.	Duarte	24	38	Rule 254, reiced twice
21	Hoak	7/23-8/2	Newcastle	Std.	Duarte	22	42	Rule 254, reiced twice
22 4/	Lengthwise	7/23-8/2	Lodi	Std.	Tragedy Duarte	23	48	Std. ref.
23	Lengthwise	7/23-8/2	Lodi	Std.	Tragedy Duarte	20	42	Std. ref.
24	Lengthwise	8/7-17	Lodi	Std.	President Kelsey	23	42	Std. ref. 2% salt
25	Lengthwise	8/7-17	Lodi	Fan	President Kelsey	none	78	Std.ref. 2% salt
26	Lengthwise	8/14-24	Loomis	Std.	President	17-1/4	38	Std. ref. 3% salt
27	Lengthwise	8/18-28	Lodi	Fan	President	none	---	Std. ref. 2% salt, 400 lbs. added at loading point.

1/ Fan cars were equipped with fans under the floor racks (preco fans) with the exception of test Car 18, which had fans at top bulkhead opening (schweb fans).

2/ Average of 9 positions in load, top, middle and bottom layers.

3/ All cars initially iced, replenished after precooled, and reiced once, twice or 10 to 12 times in transit (std. ref.) as indicated. Salt was used in amounts indicated as percentage of ice supplied at each reicing unless icing stations specified.

4/ Dry ice test.

TABLE 2
CONDITION OF BEAUTY PLUMS ON ARRIVAL
AS INFLUENCED BY TRANSIT TEMPERATURE
AND MATURITY

TRANSIT 1/ TEMP.	POSITION IN LOAD		TEST	CONDITION FOR AUCTION	
	Layer	Stack		MATURITY 3 Barely Passing, Yellow Green to Straw, Trace of Pink on Few Plums	MATURITY 4 Average 10% Pink To Red Color, Mostly Firm
°F.					
38	Bottom	Bunker	4	--	Good
39	Bottom	Bunker	1 2/	Much too green	Slightly green
39	Bottom	Bunker	3 2/	Too green	Excellent
44	Bottom	Bunker	2 2/	Too green	Excellent
44	Top	Doorway	1 2/	Much too green	Good
44	Bottom	Doorway	4	--	Good
44	Bottom	Quarter-length	4	--	Good
46	Top	Doorway	3 2/	Slightly green	Slightly ripe
48	Top	Doorway	2 2/	Slightly green	Slightly ripe
49	Top	Doorway	4	Too ripe	Too ripe
50	Middle	Quarter-length	4	--	Too ripe
52	Top	Bunker	4	Too ripe	--
53	Top	Quarter-length	4	Much too ripe	--

1/ Average temperature for transit period, i.e. from loading time until unloaded.

2/ Fan car.

TABLE 3
CONDITION OF SANTA ROSA PLUMS ON ARRIVAL AS INFLUENCED BY TRANSIT TEMPERATURE AND MATURITY

TRANSIT 1/ TEMP.	POSITION IN LOAD Layer	Stack	TEST	CONDITION FOR AUCTION COMMERCIAL Mixture of Maturities 3 to 5	MATURITY 3 Minimum about 40% Pink to Red	MATURITY 5 75 to 85% Pink to Red
°F.						
37	Bottom	Bunker	10	Good	--	--
38	Bottom	Doorway	8 2/	Slightly Green	--	--
40	Bottom	Bunker	6	--	--	Good
40	Bottom	Quarter	8 2/	--	--	Good
40	Top	Bunker	8 2/	Slightly Green	--	--
40	Top	Quarter	8 2/	--	Slightly green	Good
40	Bottom	Bunker	11	Good	--	--
41	Bottom	Quarter	5 2/	Good 3/	--	--
41	Top	Quarter	5 2/	Good 3/	--	--
41	Bottom	Bunker	8 2/	Slightly green	--	--
41	Bottom	Bunker	9	Good	--	--
41	Bottom	Quarter	14	Good	--	Slightly ripe
41	Bottom	Quarter	16	Too ripe 3/	--	--
42	Bottom	Bunker	5 2/	--	--	Slightly ripe
42	Middle	Quarter	5 2/	Good 3/	--	--
42	Bottom	Quarter	10	--	Good	Good
42	Bottom	Quarter	11	--	Good	Slightly ripe
43	Bottom	Quarter	9	--	Good	Slightly ripe
44	Middle	Quarter	6	Slightly ripe 3/	--	--
44	Top	Doorway	8 2/	Good	--	--
44	Top	Doorway	11	Good	--	--
45	Top	Doorway	5 2/	--	Good	Slightly ripe
46	Middle	Quarter	8 2/	--	Excellent	Good
46	Top	Quarter	11	--	Good	Too Ripe
47	Top	Doorway	6	--	Good	Too Ripe
47	Top	Quarter	16	Too Ripe 3/	--	--
48	Middle	Quarter	11	Slightly ripe	--	--
49	Top	Quarter	6	Slightly ripe	--	--
49	Top	Doorway	7 2/	Fair	Good	Too ripe
49	Middle	Quarter	14	Too ripe	Good	Too ripe
50	Top	Doorway	9	Slightly ripe	--	--
51	Top	Quarter	14	--	Too ripe	Too ripe
52	Top	Quarter	10	--	Too ripe	Too ripe
52	Middle	Quarter	10	Slightly ripe	--	--
53	Middle	Quarter	9	Slightly ripe	--	---
59	Top	Quarter	9	Slightly ripe	Too ripe	Too ripe

1/ Average temperature for transit period, i.e., from loading time until unloaded.

2/ Fan car.

3/ Ripe when packed, showing 50 to 90% pink to red.

TABLE 4
CONDITION OF TRAGEDY PLUMS ON ARRIVAL
AS INFLUENCED BY TRANSIT TEMPERATURE
AND MATURITY

TRANSIT 1/ TEMP.	POSITION IN LOAD Layer	STACK	TEST	CONDITION FOR AUCTION COMMERCIAL Mixture of Maturities 3 to 5	MATURITY 3 Minimum, about 40 to 45% blue	MATURITY 5 85 to 95% blue
°F.						
37	Bottom	Bunker	19	--	Too green	Slightly green 4/
38	Bottom	Bunker	16	--	Slightly green	Good, slightly ripe
41	Bottom	Quarter	16	Good	--	--
41	Bottom	Quarter	23	--	Good 3/	Good, slightly ripe
43	Bottom	Quarter	17 2/	Good	--	Good
44	Middle	Quarter	16	Good	--	--
44	Bottom	Bunker	17 2/	--	Slightly green	Good
45	Top	Doorway	17 2/	--	Slightly green	Good
47	Top	Quarter	16	Good, slightly ripe	--	--
48	Middle	Quarter	23	--	Good 3/	Slightly ripe
49	Top	Doorway	19	--	Slightly ripe	Too ripe 4/
49	Top	Quarter	23	--	Too ripe 3/	--
50	Top	Doorway	16	--	Good	Too ripe

1/ Average temperature for transit period, i.e., from loading time until unloaded.

2/ Fan car.

3/ Riper than maturity 3; 55 per cent blue, actually maturity 4.

4/ Slightly greener than maturity 5; actually maturity 4 with 65% blue color.

TABLE 5
CONDITION OF DUARTE PLUMS ON ARRIVAL
AS INFLUENCED BY TRANSIT TEMPERATURE
AND MATURITY

TRANSIT TEMP. 1/	POSITION IN LOAD LAYER	POSITION IN LOAD STACK	TEST	CONDITION FOR AUCTION COMMERCIAL Mixture of Plums Greener than 3 to Riper than 5.	CONDITION FOR AUCTION MATURITY 3 Minimum, 45 to 50% light red, Flesh 1/2 to Full Pink	CONDITION FOR AUCTION MATURITY 5 90% red, flesh Full Pink to Red.
°F.						
39	Bottom	Bunker	20	--	Slightly green	Good
39	Bottom	Bunker	21	--	Too green	Good
41	Bottom	Quarter	20	Good	--	--
41	Bottom	Quarter	23	--	Good slightly ripe 3/	--
42	Bottom	Bunker	18 2/	--	Slightly green	Slightly ripe
43	Top	Quarter	18 2/	Good	--	--
43	Middle	Quarter	20	Good	--	--
43	Bottom	Quarter	21	Good	--	--
44	Bottom	Quarter	18 2/	Good	--	--
45	Middle	Quarter	18 2/	Good	--	--
45	Top	Doorway	20	--	Slightly green	Slightly ripe
45	Top	Quarter	20	Good	--	--
46	Top	Doorway	21	--	Good	Slightly ripe
47	Top	Doorway	18 2/	--	Slightly green	Too ripe
47	Middle	Quarter	21	Good	--	--
48	Middle	Quarter	23	--	Slightly ripe 3/	--
49	Top	Quarter	21	Good	--	--
49	Top	Quarter	23	--	Slightly ripe 3/	--

1/ Average temperature for transit period, i.e., loading time until unloaded.

2/ Fan car.

3/ Riper than maturity 3; classed maturity 4.

TABLE 6
CONDITION OF PRESIDENT PLUMS ON ARRIVAL
AS INFLUENCED BY TRANSIT TEMPERATURE
AND MATURITY

TRANSIT 1/ TEMP. °F.	POSITION IN LOAD Layer	Stack	TEST	CONDITION FOR AUCTION MATURITIES 3 and 4 Minimum and slightly riper; 75-85% red purple	MATURITIES 5 and 6 95-100% blue color
39	Bottom	Quarter	24	Slightly green	Slightly ripe
39	Bottom	Quarter	26	Slightly green	Good 2/
42	Bottom	Quarter	25 3/	Slightly green	Good
43	Top	Quarter	25 3/	Slightly green	Good, slightly ripe
43	Top	Quarter	27 3/	Good 4/	Good
43	Middle	Quarter	27 3/	--	Good 5/
45	Bottom	Quarter	27 3/	Good 4/	Good
47	Top	Quarter	24	Good	Slightly ripe
49	Top	Quarter	26	Good, slightly green	Slightly ripe 2/

1/ Average temperature for transit period, i.e., loading time until unloaded.

2/ Maturity 6, 100% blue color.

3/ Fan car.

4/ Maturity 4, 85% reddish purple.

5/ Commercial pack, most plums maturity 5.

TABLE 7
SUMMARY OF PLUM PRECOOLING TESTS, 1942

COOLING PERIOD	TEST NO.	AVERAGE 1/ FRUIT TEMP.		TEMPERATURE DROP		SALT USED	ICE MELTED	TEMP. DROP PER 1M LBS. OF ICE MELTED	AVE. AIR BLAST	KIND OF PRECOOLING EQUIPMENT
		Start	Fin.	Total	Per Hr.					
Hrs.		°F	°F	°F	°F	Lbs.	Lbs.	°F	°F	
4-1/2	1	65	57	8	1.8	200	1,960	4.1	--	Car fans under floor racks (Preco)
4-1/2	7	84	70	14	3.1	500	--	--	--	Centrifugal fans
4-1/2	18	73	64	9	2.0	250	1,900	4.7	45.0	Car fans top bulkhead (Schweb)
6-1/4	4	69	55	14	2.2	None	--	--	39.6	Trackside ammonia coils
8	9	72	57	15	1.9	None	--	--	42.8	Trackside ammonia coils
8	15	81	51	30	3.8	500	--	--	42.1	Propeller fans
8-3/4	8	74	48	26	3.0	500	6,200	4.2	37.3	Fans under floor racks (Preco)
10	20-X	68	42	26	2.6	750	--	--	38.5	Propeller fans
10-3/4	14	61	43	18	1.7	None	--	--	34.7	Trackside ammonia coils
11-1/2	3	76	47	29	2.5	500	--	--	40.4	Car fans under floor racks (Preco)
15-3/4	10	75	48	27	1.7	None	--	--	38.4	Trackside ammonia coils
17-1/4	26	77	40	37	2.1	875	9,400	3.9	36.0	Propeller fans
18-1/4	6	76	47	29	1.6	300	9,400	3.1	43.7	Propeller fans
19-1/4	13	61	36	25	1.3	412	8,800	2.8	37.7	Propeller fans
19-1/2	11	72	43	29	1.5	750	--	--	38.6	Propeller fans

(Cont'd)

TABLE 7 (Cont'd)
SUMMARY OF PLUM PRECOOLING TESTS, 1942

COOLING PERIOD	TEST NO.	AVERAGE 1/ FRUIT TEMP.		TEMPERATURE DROP		SALT USED	ICE MELTED	TEMP. DROP PER 1M LBS. OF ICE MELTED	AVE. AIR BLAST	KIND OF PRECOOLING EQUIPMENT
		Start	Fin.	Total	Per Hr.					
Hrs.		°F.	°F	°F	°F	Lbs.	Lbs.	°F	°F	
19-3/4	12	58	35	23	1.2	412	8,600	2.7	42.1	Propeller fans
20	23	85	42	43	2.2	500	--	--	--	Propeller fans
21-1/4	21-X	77	39	38	1.8	875	11,600	3.3	35.1	Propeller fans
21-3/4	5	73	43	30	1.4	300	7,700	3.9	44.0	Propeller fans
22	16	59	35	24	1.1	none	--	--	29.9	Warehouse
22	21	75	42	33	1.5	750	7,700	4.3	33.7	Propeller fans
23	22	86	48	38	1.7	375	--	--	--	Propeller fans
23	24	75	42	33	1.4	530	--	--	40.2	Propeller fans
24	20	72	38	34	1.4	1,000	9,780	3.5	30.5	Propeller fans

1/ Average of 9 temperatures taken as follows: Bottom, middle and top layers of bunker; quarter length and doorway stacks, center line of car.

TABLE 8
ESTIMATING AVERAGE FRUIT TEMPERATURES BY
THE TEMPERATURE IN FIVE ACCESSIBLE CRATES

TEST	PRECOOLING METHOD	HOURS COOLED	AVE. 1/ TEMP. °F.	FIVE OUTSIDE 2/ CRATES COMPARED TO AVE. °F.
	Lengthwise Loads			
20-X	Propeller fans top bulkhead	10	42	-2.0
26	Propeller fans top bulkhead	17-1/4	40	-4.0
6	Propeller fans top bulkhead	18-1/4	47	-1.0
13	Propeller fans top bulkhead	19-1/4	36	-1.0
12	Propeller fans top bulkhead	19-3/4	35	0
5	Propeller fans top bulkhead	21-3/4	43	-1.0
24	Propeller fans top bulkhead	23	42	-2.0
1	Car equipment under floor racks (Preco)	4-1/2	57	0
	Hoak Crosswise Loads			
15	Propeller fans top bulkhead	8	51	-7.0
11	Propeller fans top bulkhead	19-1/2	43	-6.0
21-X	Propeller fans top bulkhead	21-1/4	39	-3.0
21	Propeller fans top bulkhead	22	42	-4.0
20	Propeller fans top bulkhead	24	38	-3.0
4	Mechanical ref. air delivery at doorway	6-1/4	55	-4.0
9	Mechanical ref. air delivery at doorway	8	57	-6.0
14	Mechanical ref. air delivery at doorway	10-3/4	43	-5.0
10	Mechanical ref. air delivery at doorway	15-3/4	48	-5.0
8	Car equipment under floor racks (Preco)	8-3/4	48	-7.0
3	Car equipment under floor racks (Preco)	11-1/2	47	-4.0

1/ Average of 9 temperatures taken as follows: Bottom, middle and top layers of bunker, quarter length and doorway stacks, center line of car.

2/ Bottom, middle and top layer of doorway stack, top layer of quarter length and bunker stacks.

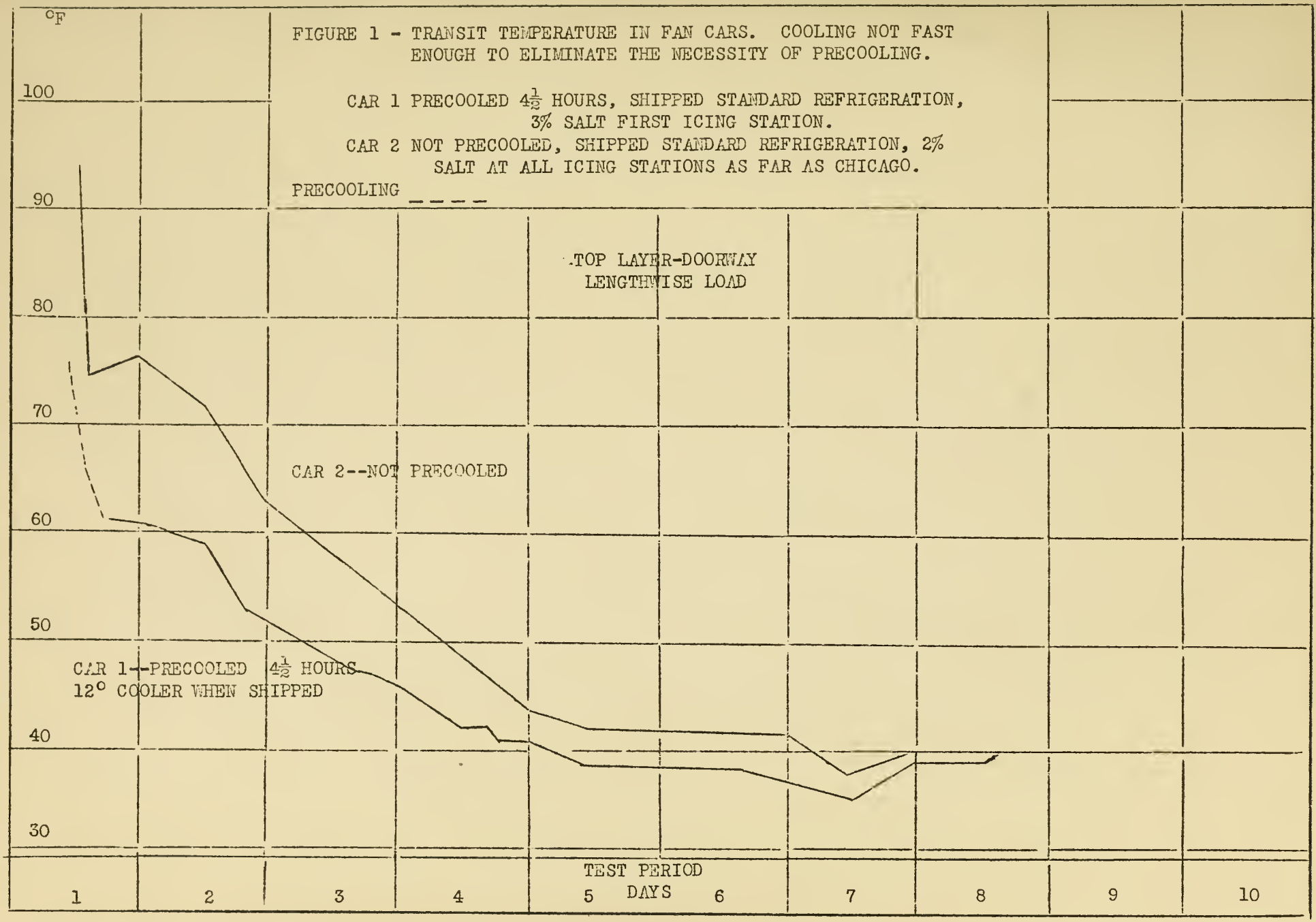

°F
100
90
80
70
60
50
40
30
FIGURE 1 - TRANSIT TEMPERATURE IN FAN CARS. COOLING NOT FAST ENOUGH TO ELIMINATE THE NECESSITY OF PRECOOLING.
CAR 1 PRECOOLED 4½ HOURS, SHIPPED STANDARD REFRIGERATION, 3% SALT FIRST ICING STATION.
CAR 2 NOT PRECOOLED, SHIPPED STANDARD REFRIGERATION, 2% SALT AT ALL ICING STATIONS AS FAR AS CHICAGO.
PRECOOLING _ _ _ _
TOP LAYER-DOORWAY LENGTHWISE LOAD
CAR 2--NOT PRECOOLED
CAR 1--PRECOOLED 4½ HOURS 12° COOLER WHEN SHIPPED
TEST PERIOD
DAYS
1
2
3
4
5
6
7
8
9
10

FIGURE 2 - TRANSIT TEMPERATURE OF PLUMS IN A PRECOOLED STANDARD CAR AND IN A FAN CAR WITH VERY LITTLE PRECOOLING. THE PRECOOLED STANDARD CAR HAD THE BEST RECORD.

CAR 6 STANDARD CAR, PRECOOLED 18 HOURS, SHIPPED WITH 2 RE-ICINGS IN TRANSIT, NO SALT

CAR 7 FAN CAR, PRECOOLED 4¼ HOURS, SHIPPED STANDARD REFRIGERATION, 2% SALT AT ALL ICING STATIONS.

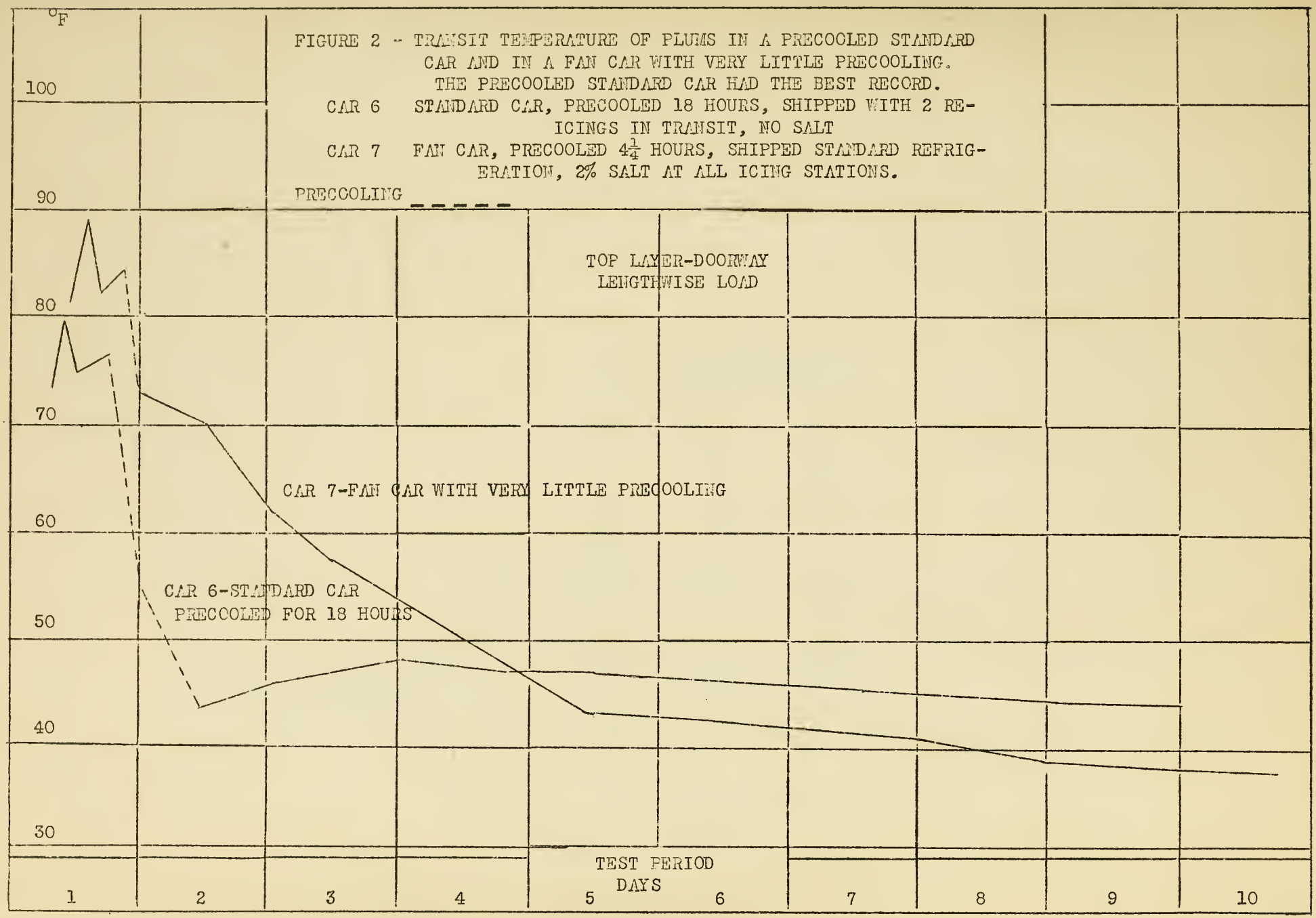
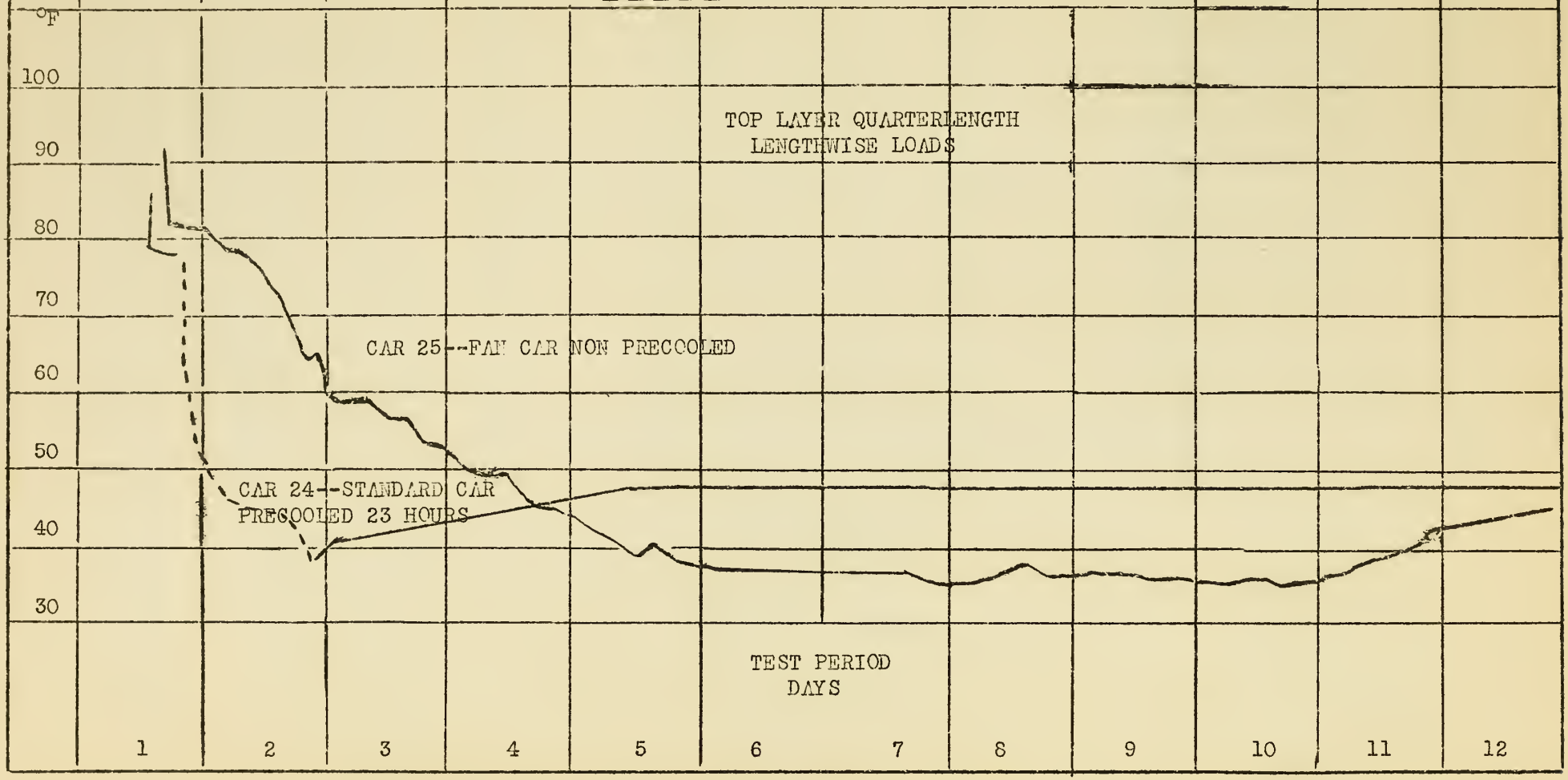
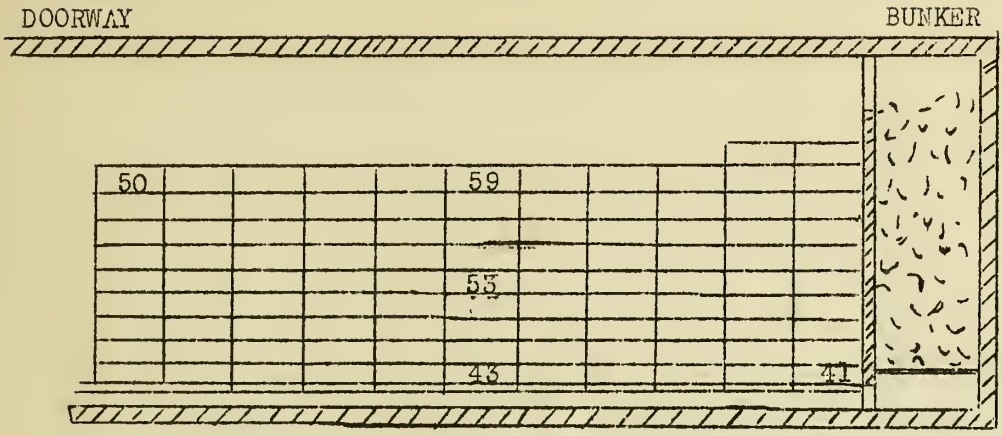


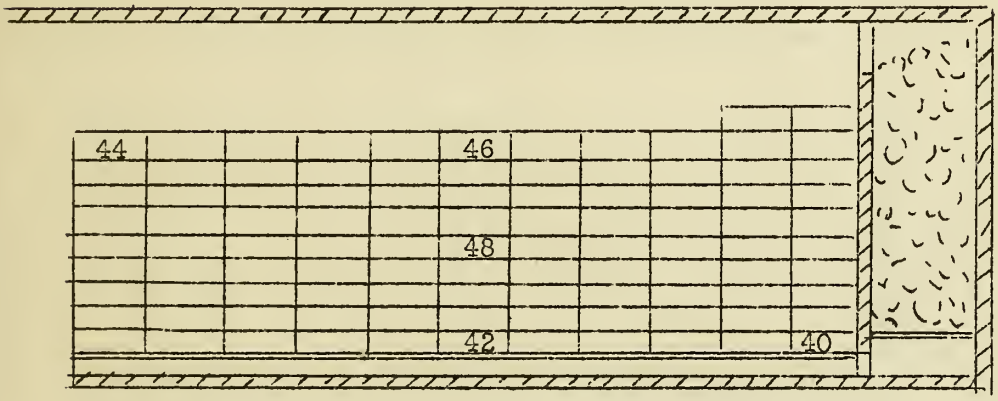
FIGURE 3 - TRANSIT TEMPERATURE OF PLUMS IN A PRE-COOLED STANDARD CAR AND IN A NON PRE-COOLED FAN CAR. COOLING WAS SLOWER IN THE FAN CAR BUT LOWER SUBSEQUENT TEMPERATURES MORE THAN OFFSET THE DISADVANTAGE.

CAR 24 STANDARD CAR, PRECOOLED 23 HOURS.
CAR 25 FAN CAR, NON PRECOOLED.
BOTH CARS SHIPPED STANDARD REFRIGERATION 2% SALT.
PRECOOLING _ _ _ _ _

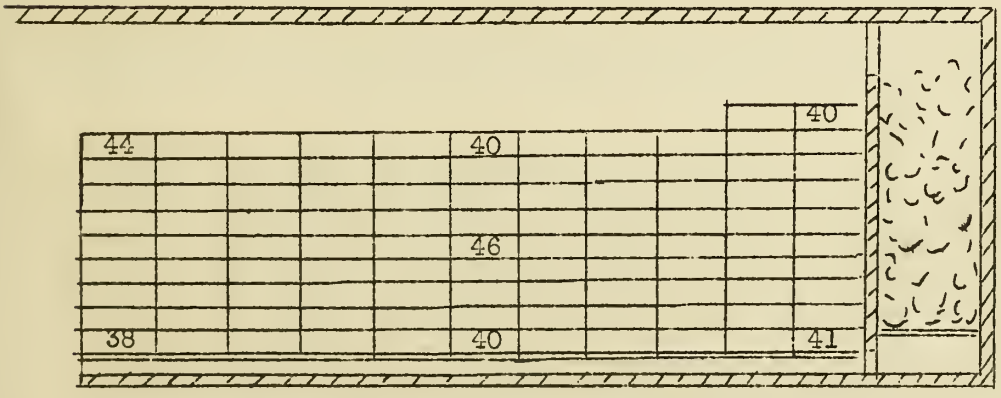




CAR 9 - POORLY PRE-COOLED, 57° AVERAGE TEMPERATURE WHEN SHIPPED. STANDARD CAR, STANDARD REFRIGERATION. PLUMS WERE OVERRIPE IN WARM POSITIONS OF LOAD.

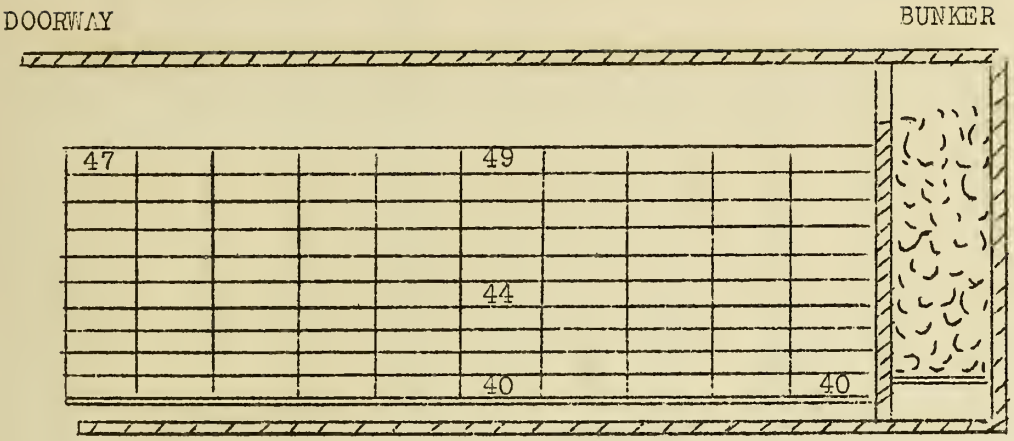


CAR 11 - WELL PRE-COOLED, 43° AVERAGE TEMPERATURE WHEN SHIPPED. STANDARD CAR, STANDARD REFRIG-ERATION 3% SALT. MUCH BETTER RECORD THAN CAR 9 BECAUSE OF THO-ROUGH PRECOOLING.

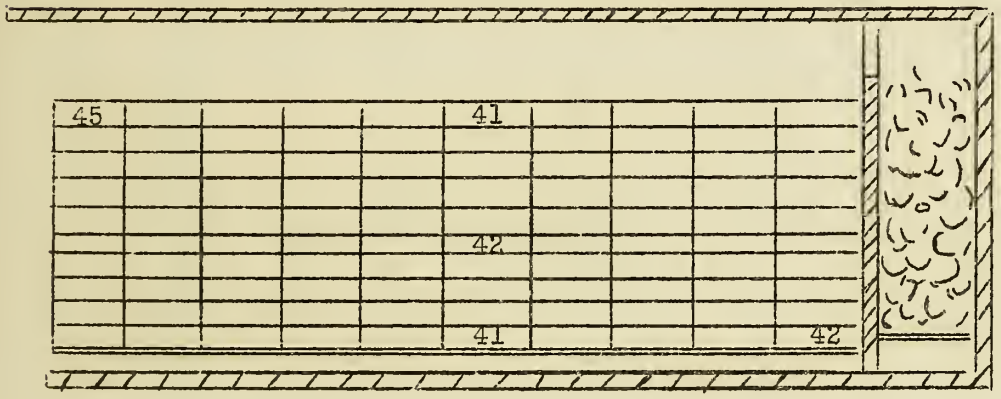


CAR 8 - MODERATELY PRE-COOLED, 48° WHEN SHIP-PED. FAN CAR, STANDARD REFRIGERATION, 3% SALT. COMBINATION OF GOOD PRECOOLING AND FAN CAR GAVE LOW TRANSIT TEMPERATURE.

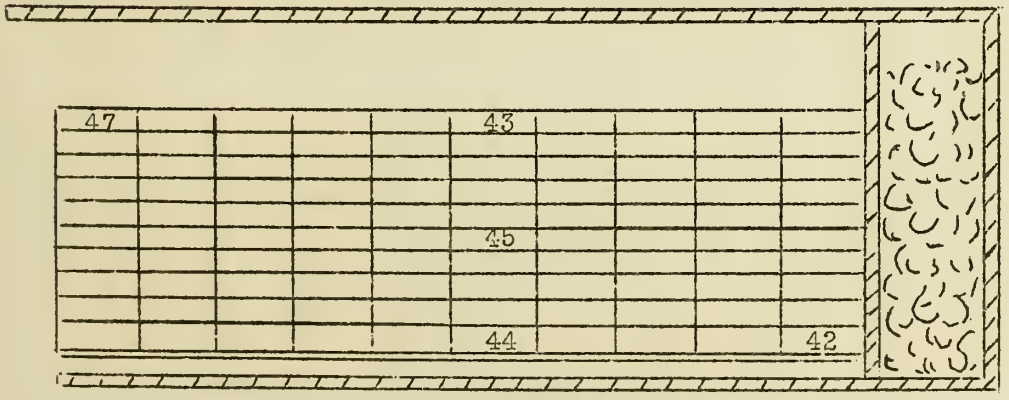
FIGURE 4 - TRANSIT TEMPERATURES OF HOAK LOADS. SECTION THROUGH CENTER LINE OF CAR SHOWING AVERAGE TRANSIT TEMPERATURES OBTAINED FROM RECORDING THERMOMETERS PACKED IN PLUM CRATES.



CAR 6 - MODERATELY PRECOOLED, 47° AVERAGE TEMPERATURE WHEN SHIPPED, STANDARD CAR, REICED TWICE IN TRANSIT. NOTE FAIRLY WARM TEMPERATURES IN TOP LAYER.

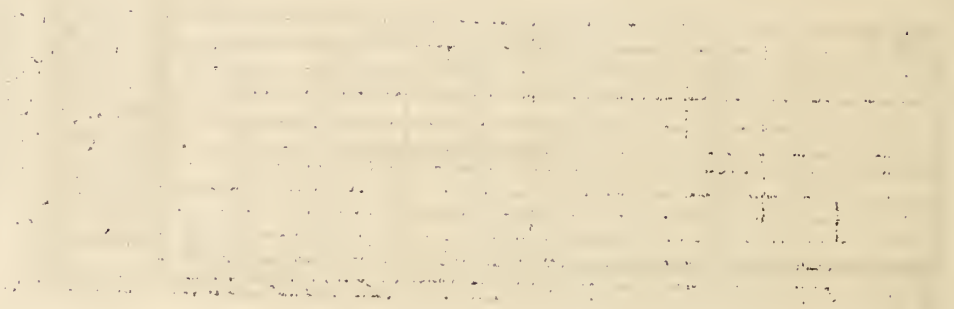


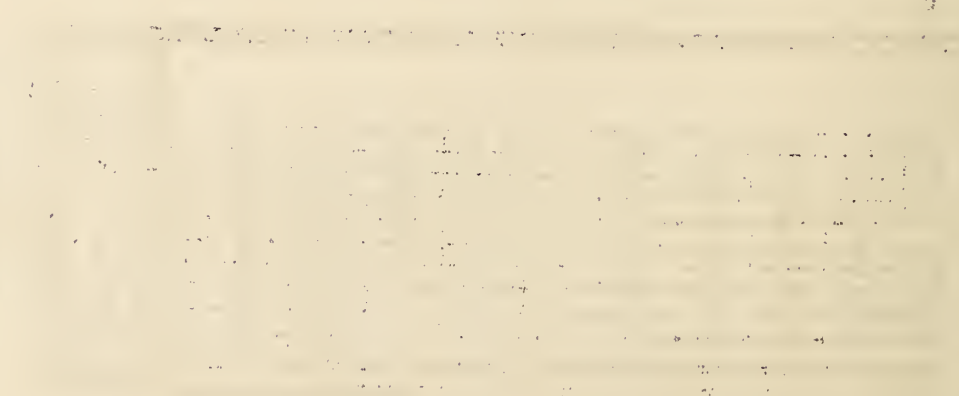
CAR 5 - WELL PRECOOLED, 43° AVERAGE TEMPERATURE WHEN SHIPPED. FAN CAR, REICE TWICE IN TRANSIT. EXCELLENT RECORD.



CAR 18 - POORLY PRECOOLED, 64° AVERAGE TEMPERATURE WHEN SHIPPED. FAN CAR, STANDARD REFRIGERATION. NOT AS GOOD RECORD AS WELL COOLED CAR 5.

FIGURE 5 - TRANSIT TEMPERATURES OF LENGTHWISE LOADS. SECTION THROUGH CENTER LINE OF CAR SHOWING AVERAGE TRANSIT TEMPERATURES OBTAINED FROM RECORDING THERMOMETERS PACKED IN PLUM CRATES.





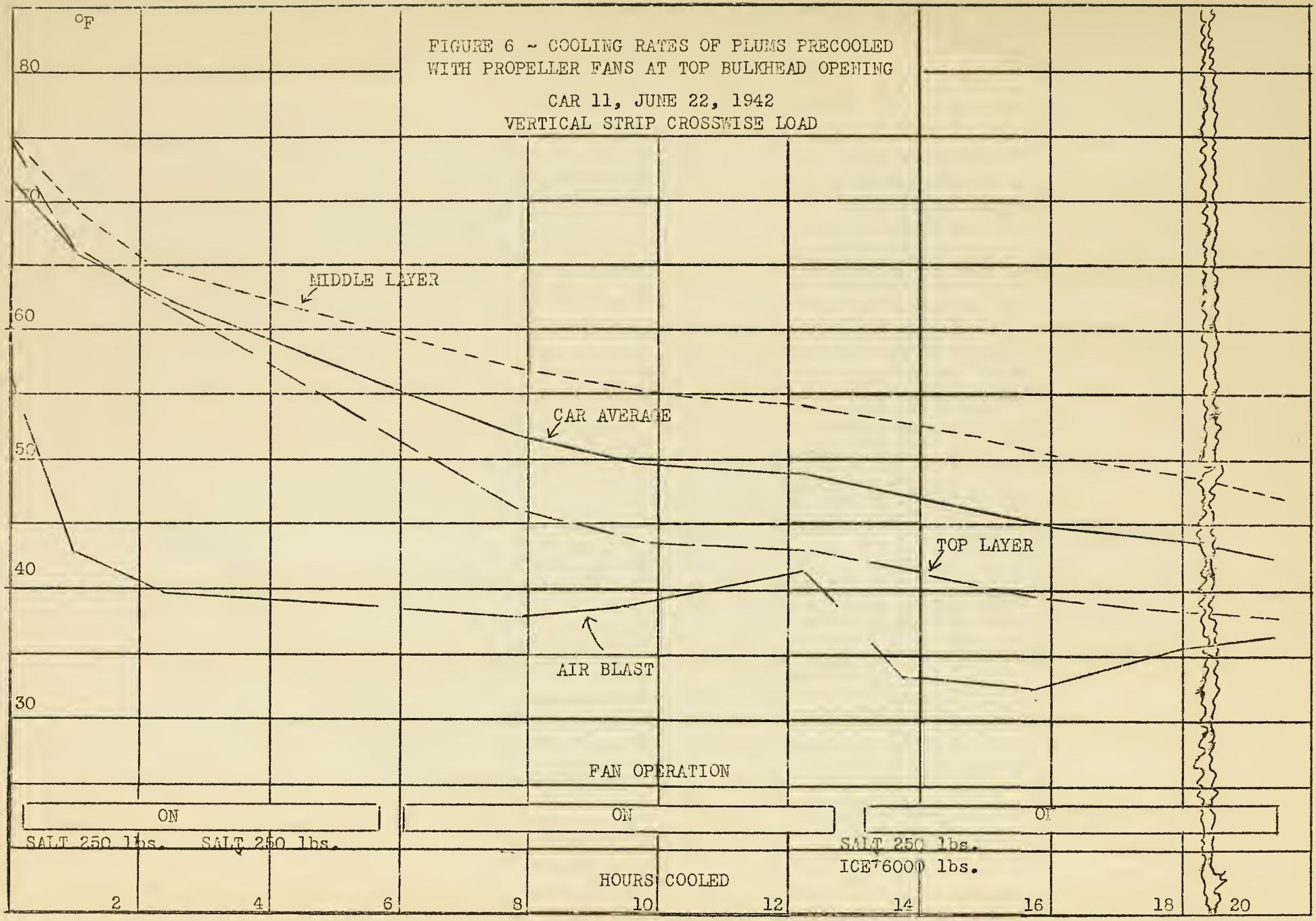


FIGURE 6 - COOLING RATES OF PLUMS PRECOOLED WITH PROPELLER FANS AT TOP BULKHEAD OPENING

CAR 11, JUNE 22, 1942
VERTICAL STRIP CROSSWISE LOAD

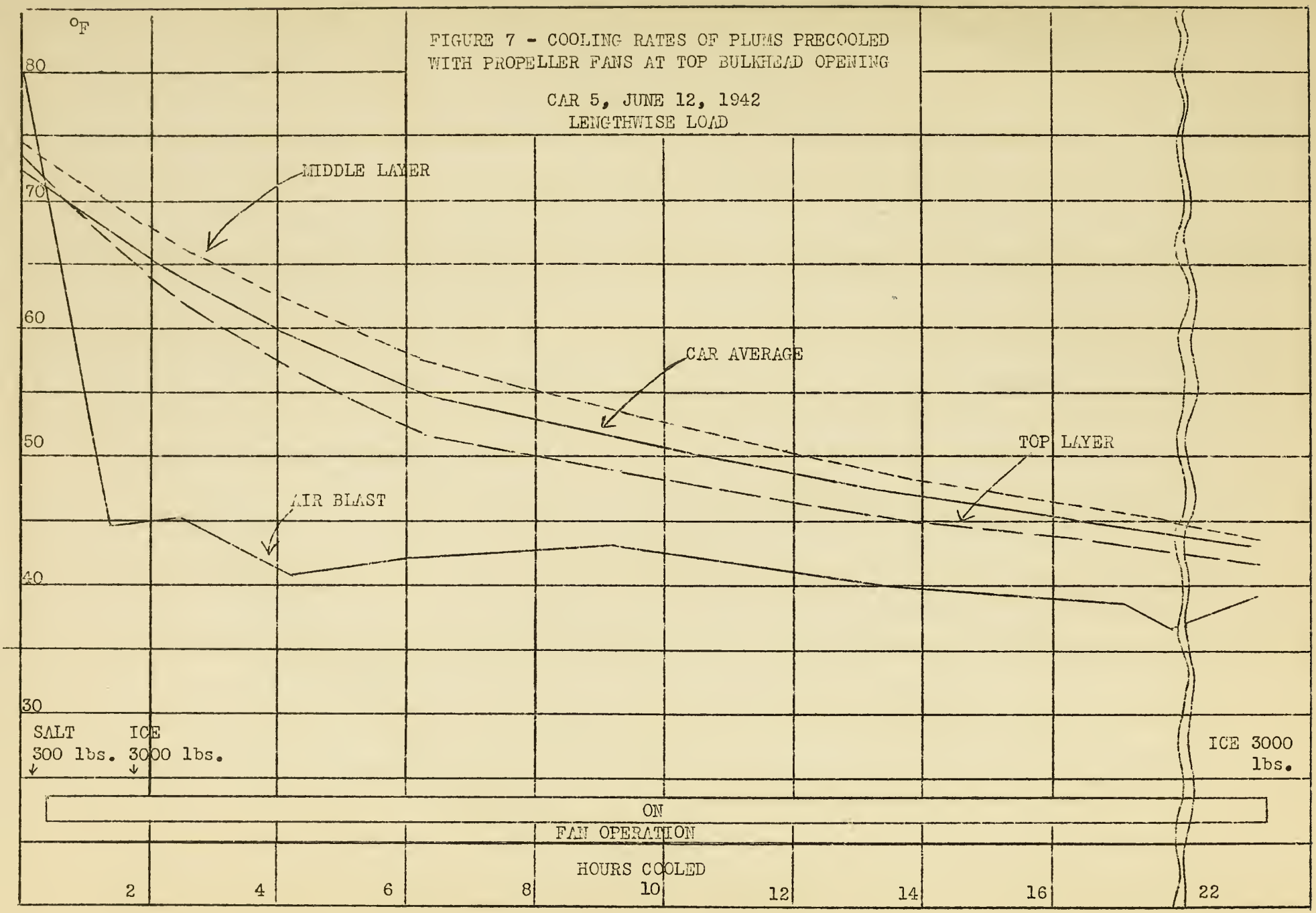


FIGURE 7 - COOLING RATES OF PLUMS PRECOOLED WITH PROPELLER FANS AT TOP BULKHEAD OPENING

CAR 5, JUNE 12, 1942
LENGTHWISE LOAD

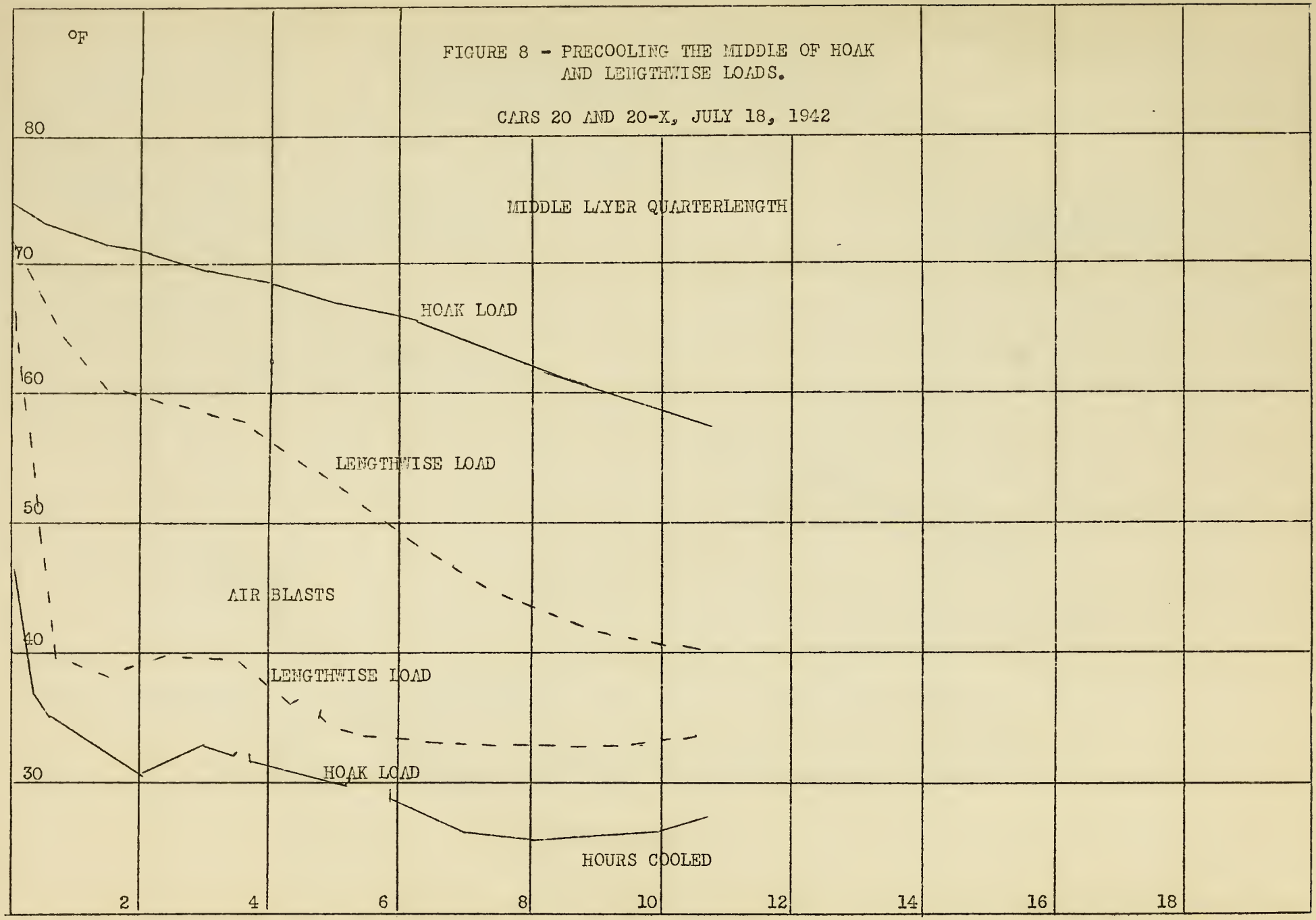


FIGURE 8 - PRECOOLING THE MIDDLE OF HOAK AND LENGTHWISE LOADS.

CARS 20 AND 20-X, JULY 18, 1942

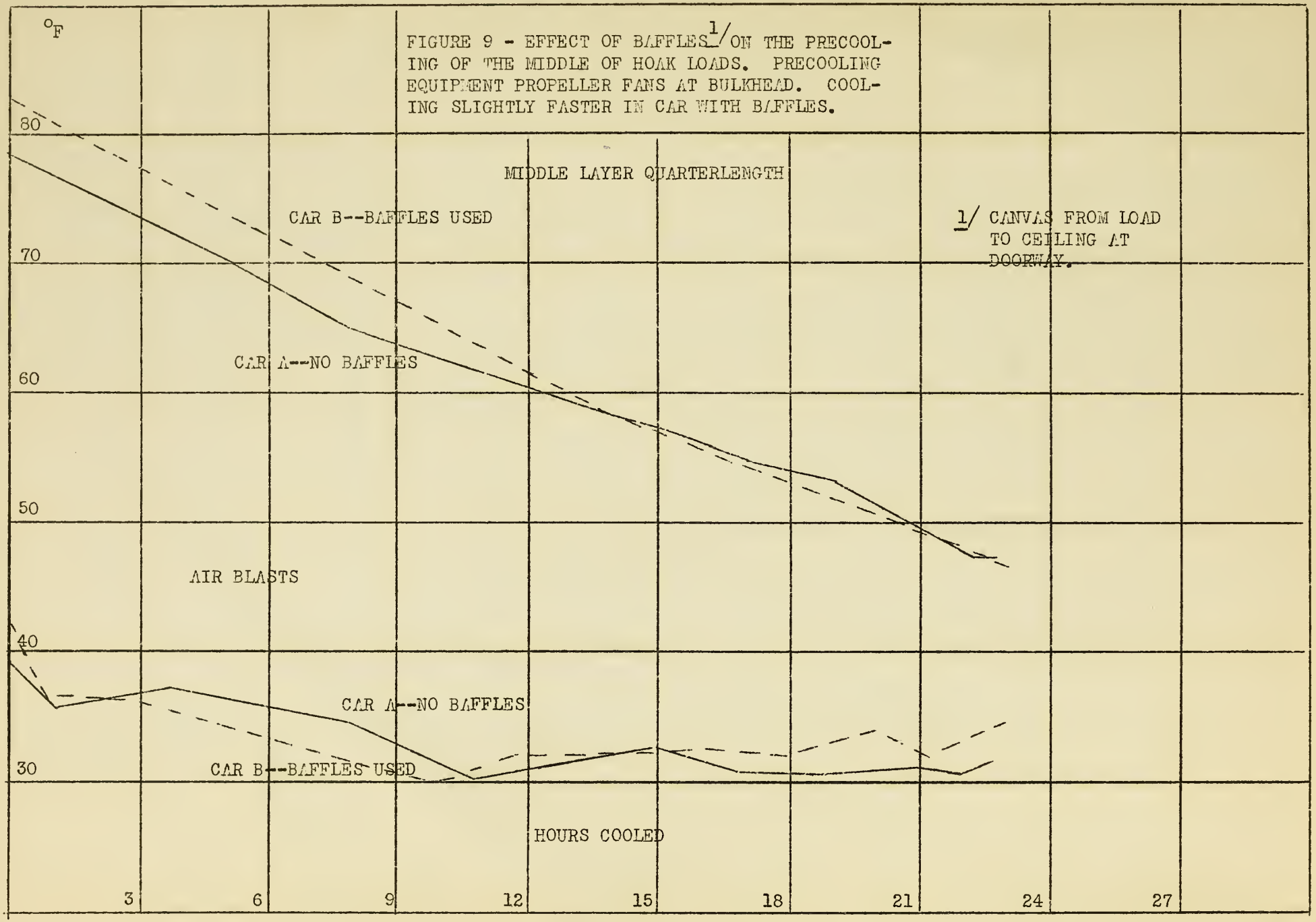
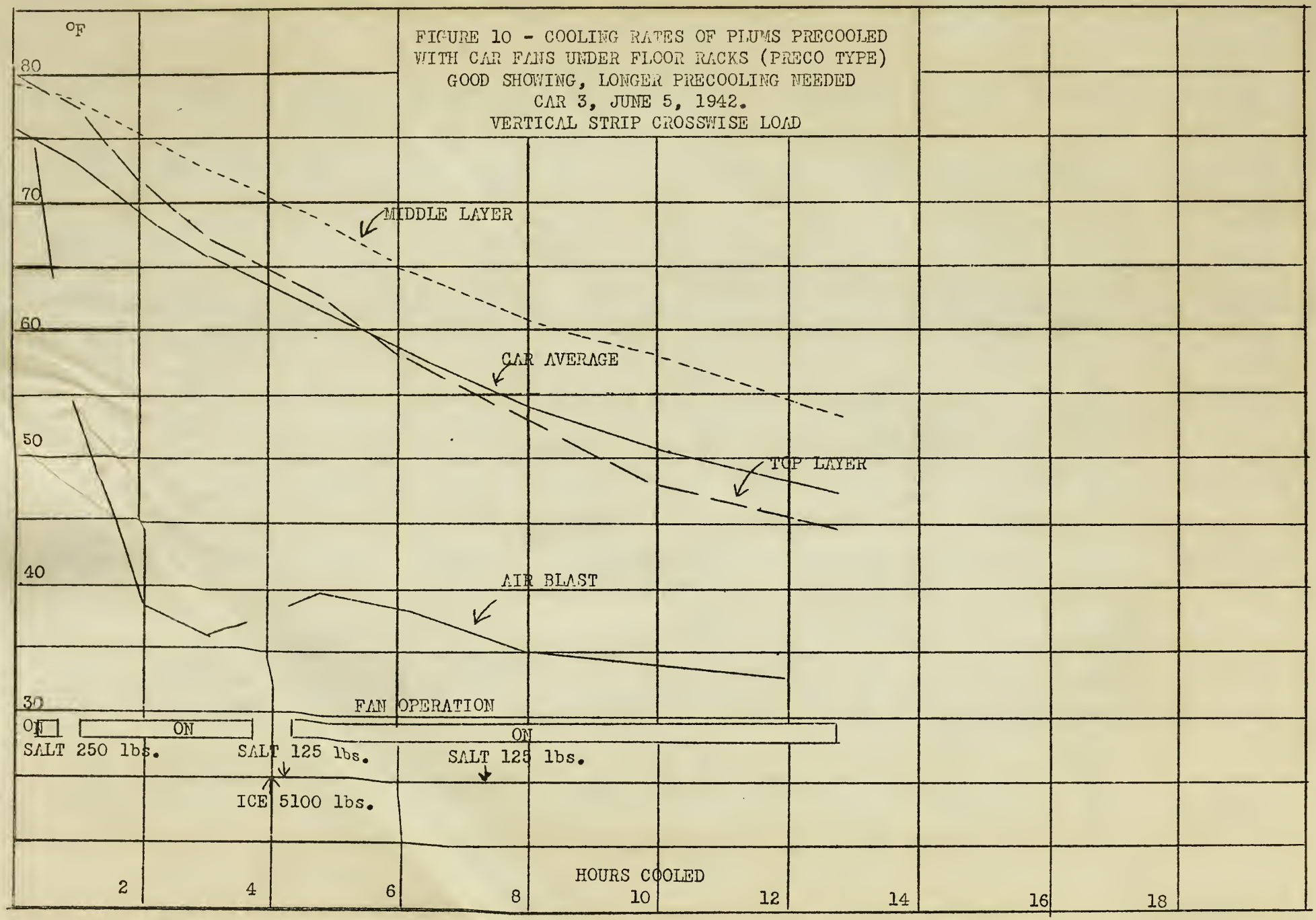


FIGURE 9 - EFFECT OF BAFFLES 1/ ON THE PRECOOLING OF THE MIDDLE OF HOAK LOADS. PRECOOLING EQUIPMENT PROPELLER FANS AT BULKHEAD. COOLING SLIGHTLY FASTER IN CAR WITH BAFFLES.

1/ CANVAS FROM LOAD TO CEILING AT DOORWAY.


°F
80
70
60
50
40
30
FIGURE 10 - COOLING RATES OF PLUMS PRECOOLED
WITH CAR FANS UNDER FLOOR RACKS (PRECO TYPE)
GOOD SHOWING, LONGER PRECOOLING NEEDED
CAR 3, JUNE 5, 1942.
VERTICAL STRIP CROSSWISE LOAD
MIDDLE LAYER
CAR AVERAGE
TOP LAYER
AIR BLAST
FAN OPERATION
ON
ON
ON
SALT 250 lbs.
SALT 125 lbs.
SALT 125 lbs.
ICE 5100 lbs.
2
4
6
8
10
12
14
16
18
HOURS COOLED